

# Samsung's Demonstratives

*Samsung Electronics Co., Ltd. et al. v. Nanoco Technologies Ltd.*

**IPR2021-00183 (U.S. Patent No. 7,588,828)**

**IPR2021-00184 (U.S. Patent No. 7,803,423)**

**IPR2021-00185 (U.S. Patent No. 7,867,557)**

**IPR2021-00186 (U.S. Patent No. 8,524,365)**

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February 23, 2022

**SAMSUNG**

- **Summary of IPRs and Disputed Issues**
- **Banin Grounds**
  - Anticipation
  - Obviousness
    - Alone
    - + Herron/Farneth, + Bawendi, + Treadway, + Braun
- **Zaban Grounds**
  - Obviousness
    - + Ptatschek/Farneth
    - + Yu, + Braun, + Bawendi

# Summary of IPRs and Disputed Issues

## Overview of Nanoparticle Patents

US07803423B2

**United States Patent**  
O'Brien et al. (10) Patent No.: **US 7,803,423 B2**  
(45) Date of Patent: Sep. 28, 2010

(54) **PREPARATION OF NANOPARTICLE MATERIALS**

(75) Inventors: Paul O'Brien, High Peak (GB); Nigel Pickett, Manchester (GB); Steven Danesh, Manchester (GB); Paul O'Brien, High Peak (GB)

(56) References Cited  
U.S. PATENT DOCUMENTS  
5,247,771 A 8/1979 Goral  
4,609,689 A 9/1986 Schwartz et al.  
6,418,038 A 9/2000 Castro et al.

**US 7,803,423 B2**

(22) Filed: Apr. 27, 2005  
(86) PCT No.: PCT/GB2005/001611  
4,371 (off.)

**PREPARATION OF NANOPARTICLE MATERIALS**

(30) Foreign Application Priority Data  
Apr. 30, 2004 (GB) 0409877.8

(57) **ABSTRACT**  
A method of producing nanoparticles comprises effecting conversion of a nanoparticle precursor composition to the material of the nanoparticles. The precursor composition comprises a first precursor species containing a first ion to be incorporated into the growing nanoparticles and a separate second precursor species containing a second ion to be incorporated into the growing nanoparticles. The conversion is effected in the presence of a molecular cluster compound under conditions permitting seeding and growth of the nanoparticles.

(51) Int. Cl. (2006.01)  
**B22B 3/00** (2006.01)  
**C30B 7/00** (2006.01)  
**C30B 71A** (2006.01)

(52) U.S. Cl. (2006.01)  
427213.34; 427212; 427213.3;  
427213.31; 427214; 427215; 428402;  
428403

(58) Field of Classification Search  
See application file for complete search history.

25 Claims, 14 Drawing Sheets

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1 of 28

US08524365B2

**United States Patent**  
O'Brien et al. (10) Patent No.: **US 8,524,365 B2**  
(45) Date of Patent: Sep. 3, 2015

(54) **PREPARATION OF NANOPARTICLE MATERIALS**

(75) Inventors: Paul O'Brien, High Peak (GB); Nigel Pickett, Manchester (GB); Steven Danesh, Manchester (GB); Paul O'Brien, High Peak (GB)

(56) References Cited  
U.S. PATENT DOCUMENTS  
5,247,771 A 8/1979 Goral  
4,609,689 A 9/1986 Schwartz et al.  
6,418,038 A 9/2000 Castro et al.

**US 8,524,365 B2**

(22) Filed: Oct. 6, 2011  
(86) PCT No.: PCT/GB2011/05155 A1  
US 2012/0025155 A1 Feb. 2, 2012

**PREPARATION OF NANOPARTICLE MATERIALS**

(30) Foreign Application Priority Data  
Apr. 30, 2004 (GB) 0409877.8

(57) **ABSTRACT**  
A method of producing nanoparticles comprises effecting conversion of a nanoparticle precursor composition to the material of the nanoparticles. The precursor composition comprises a first precursor species containing a first ion to be incorporated into the growing nanoparticles and a separate second precursor species containing a second ion to be incorporated into the growing nanoparticles. The conversion is effected in the presence of a molecular cluster compound under conditions permitting seeding and growth of the nanoparticles.

(51) Int. Cl. (2006.01)  
**B22B 1/00** (2006.01)  
**B22B 3/00** (2006.01)  
**C30B 70/10** (2006.01)

(52) U.S. Cl. (2006.01)  
428403; 428402; 428406; 428409;  
427212; 427214; 427215; 977700; 977773;  
977813; 977814; 977815; 977824; 977827;  
977830

(58) Field of Classification Search  
See application file for complete search history.

23 Claims, 18 Drawing Sheets

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US07588828B2

**United States Patent**  
Mushtaq et al. (10) Patent No.: **US 7,588,828 B2**  
(45) Date of Patent: Sep. 15, 2009

(54) **PREPARATION OF NANOPARTICLE MATERIALS**

(75) Inventors: Inamra-Mustafa, Manchester (GB); Nigel Pickett, Manchester (GB); Steven Danesh, Manchester (GB); Paul O'Brien, High Peak (GB)

(56) References Cited  
U.S. PATENT DOCUMENTS  
4,609,689 A 9/1986 Castro et al.  
6,114,038 A 9/2000 Castro et al.  
6,207,239 B1\* 3/2001 Bownard et al.  
6,322,461 B1\* 11/2001 Bownard et al.  
6,379,633 B2 4/2002 O'Brien et al.  
6,666,379 B1\* 12/2003 Huang et al.  
2003/0105754 A1 12/2003 Treadway et al.  
2004/010488 A1 6/2004 Yamada  
2007/0104865 A1 5/2007 Pickett  
2007/0252333 A1 8/2007 O'Brien et al.  
2007/0238136 A1 10/2007 Pickett et al.  
2008/0239993 A1 9/2008 Pickett et al.  
2008/0237200 A1 10/2008 Harris et al.  
2008/0264479 A1 10/2008 Harris et al.

(57) **ABSTRACT**  
Nanoparticles including a molecular cluster compound incorporating ions from groups 12 and 16 of the periodic table, as well as a core semiconductor material incorporating ions from groups 13 and 15 of the periodic table, are fabricated. The core semiconductor material is provided on the molecular cluster compound.

14 Claims, 4 Drawing Sheets

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US07867557B2

**United States Patent**  
Pickett et al. (10) Patent No.: **US 7,867,557 B2**  
(45) Date of Patent: Jan. 11, 2011

(54) **NANOPARTICLES**

(75) Inventors: Nigel Pickett, Manchester (GB); Steven Danesh, Manchester (GB); Paul O'Brien, High Peak (GB); Paul O'Brien, High Peak (GB)

(56) References Cited  
U.S. PATENT DOCUMENTS  
2,360,818 A 11/1956 Maner et al.  
(Continued)

**US 7,867,557 B2**

(21) Appl. No.: 11,997,973  
(22) PCT Filed: Aug. 14, 2006  
(86) PCT No.: PCT/GB2006/001611  
4,371 (off.)

**NANOPARTICLES**

(30) Foreign Application Priority Data  
US 2008/0220593 A1 Sep. 11, 2008  
Aug. 12, 2005 (GB) 0516598.0

(57) **ABSTRACT**  
Nanoparticles including a molecular cluster compound incorporating ions from groups 12 and 16 of the periodic table, as well as a core semiconductor material incorporating ions from groups 13 and 15 of the periodic table, are fabricated. The core semiconductor material is provided on the molecular cluster compound.

17 Claims, 12 Drawing Sheets

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IPR2021-00184, Ex. 1001

IPR2021-00186, Ex. 1001

IPR2021-00183, Ex. 1001

IPR2021-00185, Ex. 1001

# Summary of IPRs and Disputed Issues

## Overview - Patents Describe Seeding Growth With Molecular Cluster Compounds

- Molecular cluster seeded growth

The invention consists of the use of molecular clusters as templates to seed the growth of nanoparticles, whereby other molecular sources “molecular feedstocks” are used to facilitate particle growth. These molecular feedstocks are a com-

'423 patent, 7:39-42

- Molecular clusters as seeds provide advantages

ecule. The use of the molecular cluster compound provides a population of nanoparticles that is essentially monodisperse. By providing nucleation sites which are so much more well defined than the nucleation sites employed in previous work the nanoparticles formed using the method of the present invention possess a significantly more well defined final structure than those obtained using previous methods. A further significant advantage of the method of the present invention is that it can be more easily scaled-up for use in industry than current methods. Methods of producing suitable

'423 patent, 5:12-21

# Summary of IPRs and Disputed Issues

## Overview – Representative Claims

### Method

1. A method of producing nanoparticles comprising: effecting conversion of a nanoparticle precursor composition to a material of the nanoparticles, said precursor composition comprising a first precursor species containing a first ion to be incorporated into the nanoparticles and a separate second precursor species containing a second ion to be incorporated into the nanoparticles, wherein said conversion is effected in the presence of a molecular cluster compound different from the first precursor species and the second precursor species under conditions permitting seeding and growth of the nanoparticles.

'423 patent, claim 1

### Nanoparticle

1. A nanoparticle comprising:  
(i) a molecular cluster compound incorporating ions from groups 12 and 16 of the periodic table, and  
(ii) a core semiconductor material provided on said molecular cluster compound,  
wherein the core semiconductor material incorporates ions from groups 13 and 15 of the periodic table.

'828 patent, claim 1

# Summary of IPRs and Disputed Issues

## Construction of “Molecular Cluster Compound” (“MCC”)

### Court’s Construction

The Court hereby construes the term “**molecular cluster compound,**” for the ‘828, ‘557, ‘423, and ‘365 patents, to mean “**clusters of three or more metal atoms and their associated ligands of sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular formula.”**”

Ex. 1091 at 18

### PO’s Response

While the district court construed the term “molecular cluster compound,” the parties’ dispute over the meaning of the term need not be resolved here. This is

IPR2021-00183, Paper 25 at 29; IPR2021-00184, Paper 25 at 28;  
IPR2021-00185, Paper 26 at 28; IPR2021-00186, Paper 25 at 25

# Summary of IPRs and Disputed Issues

## Grounds by Primary Reference

### Banin

#### Banin anticipates or renders obvious

'423 patent, cls. 1-6, 10-14, 21-25  
'365 patent, cls. 1, 7-12, 15-17, 22, 23

#### Banin in view of Herron/Farneth renders obvious

'365 patent, cls. 2-6, 18-21  
'828 patent, cls. 1, 3-6, 8-14

#### + Braun renders obvious

'557 patent, cls. 1-6, 16, 17

#### + Bawendi renders obvious

'423 patent, cls. 7-9

#### + Treadway renders obvious

'365 patent, cls. 13, 14

### Zaban

#### Zaban in view of Ptatschek renders obvious

'423 patent, cls. 1, 10-16, 21-24

#### Zaban in view of Ptatschek/Farneth + Yu renders obvious

'423 patent, cls. 4-6, 25; '365 patent, cls. 1-9, 17-23  
'828 patent, cls. 1, 3-6, 14

#### + Ptatschek + Bawendi renders obvious

'423 patent, cls. 7-9

#### + Ptatschek + Braun renders obvious

'557 patent, cls. 1, 16, 17

#### + Ptatschek/Farneth + Yu + Braun renders obvious

'828 patent, cls. 8-13  
'557 patent, cls. 4-6

- Summary of IPRs and Disputed Issues
- **Banin Grounds**
  - Anticipation
  - Obviousness
    - Alone
    - + Herron/Farneth, + Bawendi, + Treadway, + Braun
- **Zaban Grounds**
  - Obviousness
    - + Ptatschek/Farneth
    - + Yu, + Braun, + Bawendi

# Banin Grounds: Banin Alone Anticipates Or Renders Obvious

**( '423 patent, cls. 1-6, 10-14, 21-25; '365 patent, cls. 1, 7-12, 15-17, 22, 23)**

**Banin:** Discloses method of making nanoparticles in the presence of an  $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$  MCC under conditions permitting seeding and growth

## **Petition:\***

- '423 patent – claims anticipated and obvious
- '365 patent – claims anticipated and obvious

\*Banin's disclosures regarding MCC and seeded growth apply equally to the '557 and '828 patent IPRs

## **PO's Primary Disputes:**

- Whether Banin discloses a MCC
- Whether Banin teaches away from seeded growth

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau

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(10) International Publication Number  
WO 03/097904 A1

(51) International Patent Classification: C30B 7/00  
2960, C01B 19/04, H01L 33/00

(74) Agent: REINHOLD COHN AND PARTNERS, P.O.  
Box 4060, 61040 Tel Aviv (IL).

(21) International Application Number: PCT/IL03/00391

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(22) International Filing Date: 15 May 2003 (15.05.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data: 10144,777 15 May 2002 (15.05.2002) US  
60442,806 24 September 2002 (24.09.2002) US

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(71) Applicant (for all designated States except US): YISSUM RESEARCH DEVELOPMENT COMPANY OF THE HEBREW UNIVERSITY OF JERUSALEM (IL/IL); Hi Tech Park, Edmond Sutra Campus, Givat Ram, 91900 Jerusalem (IL).

Published: with international search report before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

(72) Inventors; and (75) Inventors/Applicants (for US only): BANIN, Uri (IL/IL); 37 Yasmin Street, 90805 Mevaseret Zion (IL); KAN, Shi, Hai (CN/IL); 11/12 Guatemala Street, 96704 Jerusalem (IL).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD FOR PRODUCING INORGANIC SEMICONDUCTOR NANOCRYSTALLINE RODS AND THEIR USE

(57) Abstract: The present invention provides a new method for the production of inorganic semiconductor nanocrystals having a rod-like shape. More specifically the present invention provides a method of synthesizing rod shaped Group III-V semiconductor nanocrystals. The method comprises: reacting, in a high-boiling point organic solvent, a two-source precursor solution comprising at least one metal source and at least one nonmetal source, or a single-source precursor solution, with a metal catalyst or an agent capable of producing said metal catalyst, said high-boiling point organic solvent having a temperature above 200°C, thereby forming a reaction product comprising semiconductor nanocrystals of various shape; cooling the reaction product, and subsequently exposing said cooled reaction product to at least one centrifugal step so as to obtain semiconductor nanocrystals having substantially rod-like shape. The rod-shaped nanocrystals obtained by the method of the invention usually have organic ligands as a coating on their outer surfaces. Such organic ligands affect the solubility of the particles and may be substituted or removed, according to the application intended for said particles after the reaction is completed.

WO 03/097904 A1

Samsung Ex. 1005  
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Ex. 1005 (Banin) at Cover

# Banin Grounds: Banin Alone Anticipates Or Renders Obvious

## Banin discloses use of a “molecular cluster compound” to seed growth

### Banin

The main idea of the present invention is based on introducing nanoparticles of a metal catalyst that serve as starting nanocrystals from which nanorods of inorganic semiconductors grow in solution while stopping the growth to obtain rods. Without being bound to theory, it is proposed that the reaction precursors dissolve in the metal nanoparticles and the semiconductor nanorods grow from these particles.

The metal catalyst can be made, for example, of a transition metal, e.g. Zn, Cd, Mn, etc., a Group IIIa metal, e.g. In, Ga, Al, alloys of such metals such as for example Au-In, or core/shell layered metal particle. More specific examples of

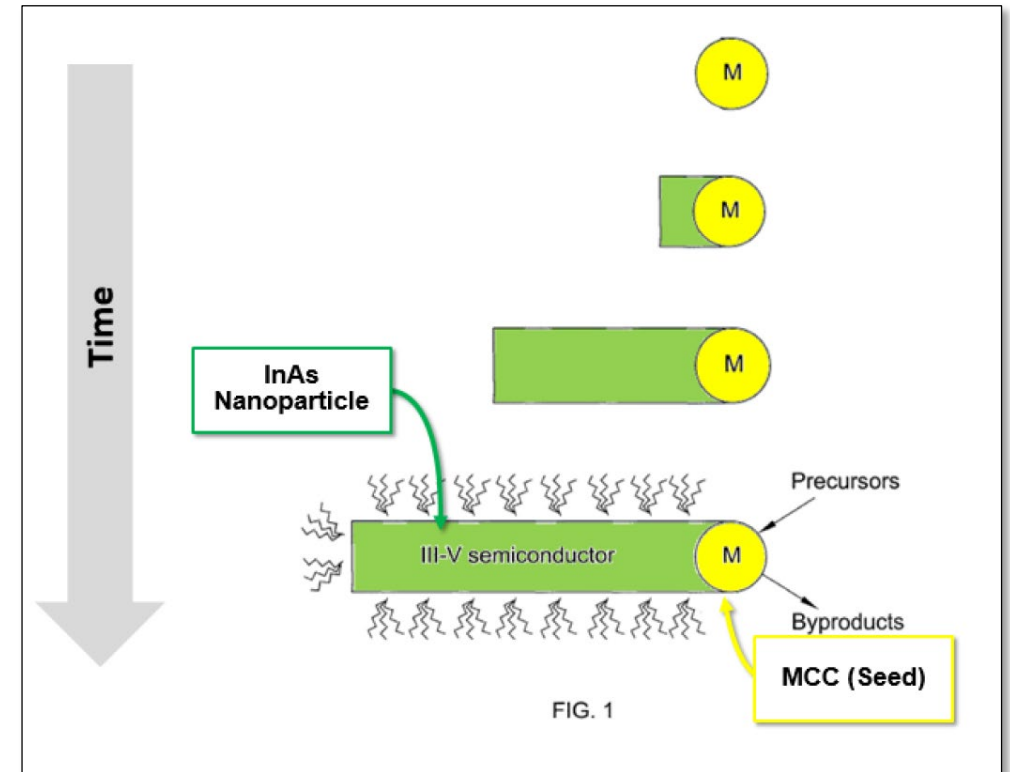
Ex. 1005 (Banin) at 6:9-14

The use of small Au clusters (1.4 nm in mean diameter) instead of Au particles (2 nm in mean diameter) as mentioned above, was also carried out. In a typical experiment triphenylphosphine coated Au clusters with diameter of 1.4 nm and the suggested formula  $Au_{101}(PPh_3)_{21}Cl_5$  (denoted as  $Au_{101}$ ) were synthesized by the published procedures [24]. InAs rods were prepared as

Ex. 1005 (Banin) at 20:12-16; see also IPR2021-00184, Ex. 1002 ¶ 90; IPR2021-00186, Ex. 1002 ¶ 90



Dr. Green  
Pet's Expert



IPR2021-00184, Ex. 1093 ¶ 34 (citing Ex. 1005 (Banin), Fig. 1)

## PO's focus on Hutchison ignores Banin's disclosure

### Banin

#### • Single formula

particles (2 nm in mean diameter) as mentioned above, was also carried out. In a typical experiment triphenylphosphine coated Au clusters with diameter of 1.4 nm and the suggested formula  $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$  (denoted as  $\text{Au}_{101}$ ) were synthesized by the published procedures [24]. InAs rods were prepared as

Ex. 1005 (Banin) at 20:13-16

#### • Size selection

A demonstration of the results obtained by using  $\text{Au}_{101}$  clusters as the catalyst particles, are shown in Figs. 10. Fig. 10A presents a TEM image of the  $\text{Au}_{101}$  clusters without further size selection, while Fig.10B presents a TEM image of the InAs nanorods clearly revealing the one-dimensional growth mode.

Ex. 1005 (Banin) at 22:25-28



Dr. Green  
Pet'r's Expert

identical to one another, that argument is wrong. See POR 32-35. Regardless of whether the gold particles in *Hutchison* are MCCs, a POSITA would recognize that Banin identifies only one specific cluster—having a single molecular formula (*i.e.*,  $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$ ) and size (1.4nm) with more than three metal atoms—which a POSITA would recognize as a MCC. Ex. 1005, 20:13-16; Ex. 1002 ¶90. Figure 10a

its  $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$  clusters are identical to one another. As an example, with respect to the TEM image in Banin's Figure 10a, Banin discloses that the MCCs are shown “without further size selection,” which means size selection was previously used to obtain a particular size particle. Ex. 1005, 22:26-28 (emphasis added).

IPR2021-00183, Ex. 1093 ¶¶ 17, 22; see also IPR2021-00184, Ex. 1093 ¶¶ 17, 22; IPR2021-00185, Ex. 1093 ¶¶ 17, 22; IPR2021-00186, Ex. 1093 ¶¶ 17, 22

## Hutchison does not disclose size selection for the tested sample

- PO argues — without support — that Hutchison’s process automatically results in size selection

### PO’s Sur-Reply

1005, 22:26-28. Petitioner emphasizes the word “further” to surmise that “size selection was previously employed” (Reply, 3-4), but ignores that Hutchison’s process which results in a dispersity of small gold particles with an “average” assigned value is *already* a form of size selection. Ex. 2017, 12891 (“the synthesis allows size control”). Because Banin’s TEM shows gold particles made by

IPR2021-00186, Paper 39 at 7

- Hutchison’s tested sample included impurity — shows no size selection

### Hutchison

The atomic composition of **1** was determined by using the complementary techniques of X-ray photoelectron spectroscopy (XPS) and thermogravimetric analysis (TGA).<sup>18</sup> XPS spectra indicate an atomic ratio of 19.1 Au to 4 P to 1 Cl for the nanoparticles and show that 3.7 mass percent of the sample is the impurity AuCl(PPh<sub>3</sub>). Taking into account this impurity, the mass percent of gold calculated by quantification of the XPS data is 75.8%. TGA indicates that 75.5% of the sample is gold by mass (Figure 1c), independently confirming the ratio determined by XPS. To calculate an average molecular formula for **1** it is necessary to know the number of gold atoms in the metal core. Given the average particle size (1.5 nm) this number is estimated to be ~101 by the method of Whetten et al.<sup>21</sup> and leads to an estimated formula of Au<sub>101</sub>(PPh<sub>3</sub>)<sub>21</sub>Cl<sub>5</sub>.

Ex. 2017 (Hutchison) at 1-2



Dr. Green  
Pet’r’s Expert

clusters. For example, PO argues that 3.7% of Hutchison’s gold seeds were AuCl(PPh<sub>3</sub>), which is a gold seed within Hutchison’s size distribution of clusters that is smaller than the Au<sub>101</sub>(PPh<sub>3</sub>)<sub>21</sub>Cl<sub>5</sub> clusters. See Ex. 2017, 12890-91. This is irrelevant because as I explained above, a POSITA would have understood that Banin does not have a size distribution of gold clusters, but instead has uniform MCCs.

IPR2021-00183, Ex. 1093 ¶ 23; IPR2021-00184, Ex. 1093 ¶ 23;  
IPR2021-00185, Ex. 1093 ¶ 23; IPR2021-00186, Ex. 1093 ¶ 23

# Banin Discloses a MCC

## PO's arguments about MCC with a "mean" diameter miss the mark

- MCC focuses on molecular formula, not size
- Banin discloses uniform MCCs

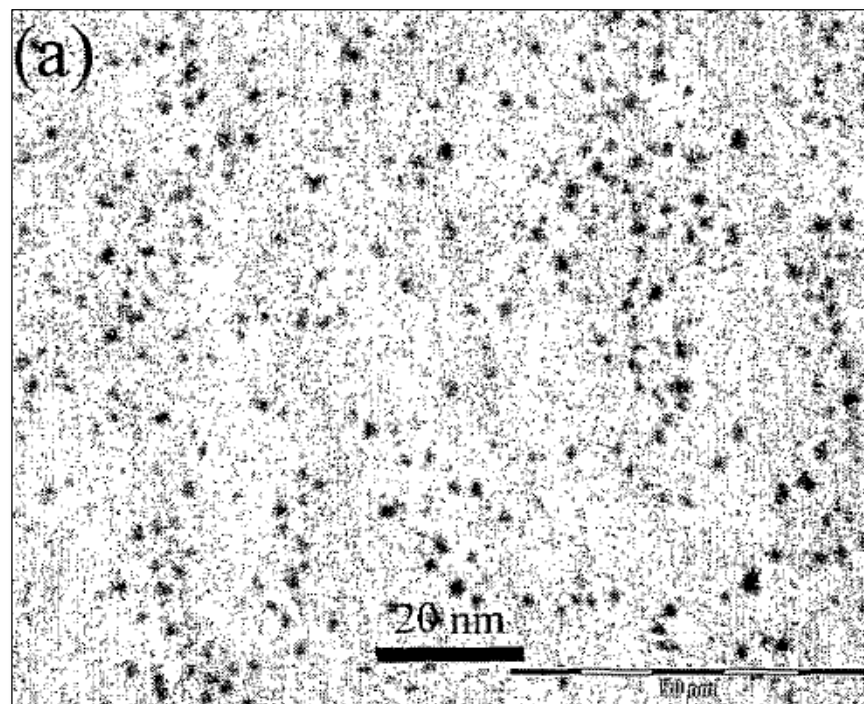


Dr. Green  
Pet's Expert

18. Contrasting the Figure 10a from Banin with the figure from Hutchison relied on by PO in its response (shown above), it is evident that Banin's TEM is consistent with uniform  $\text{Au}_{101}(\text{PPh}_3)_2\text{Cl}_5$  MCCs, while the gold particles illustrated in Hutchison are consistent with a size distribution of clusters. Based on these images, a POSITA would recognize that the MCCs in Banin are purified and size selected, even if those MCCs in Banin were made starting with the production method disclosed in Hutchison.

21. In my opinion, this improvement over Hutchison's gold particles is common and expected in the field. An initial paper that describes a synthesis of a molecule will often have byproducts, and subsequent papers that employ the same molecule will use a purified form.

IPR2021-00183, Ex. 1093 ¶¶ 18, 21; see also IPR2021-00184, Ex. 1093 ¶¶ 18, 21; IPR2021-00185, Ex. 1093 ¶¶ 18, 21; IPR2021-00186, Ex. 1093 ¶¶ 18, 21



Ex. 1005 (Banin) at Fig. 10A

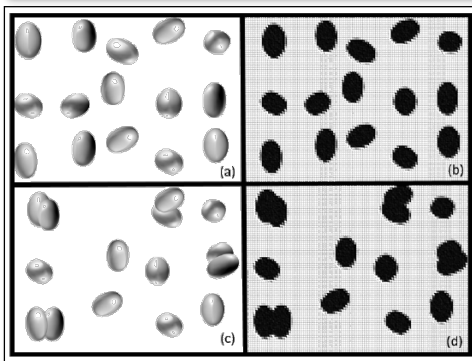
# Banin Discloses a MCC

## Evidence shows identical particles can have different 2D sizes



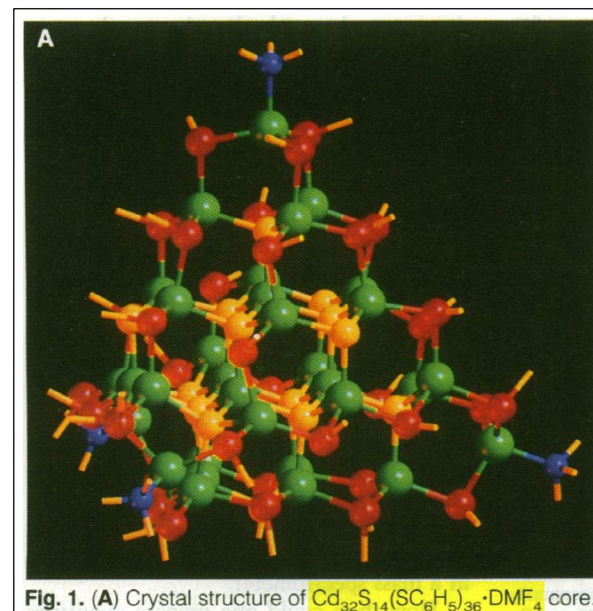
Dr. Green  
Pet'r's Expert

these TEM images. Banin's MCCs, like most MCCs, are not perfectly spherical. A POSITA would have understood that a non-spherical MCC will look different when viewed from different angles. As a result, a POSITA would have understood that the profiles of Banin's non-spherical  $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$  MCCs as shown in the TEM will vary from MCC to MCC because each MCC will be oriented differently even though those MCCs are in fact identical. This is illustrated in panels (a) and (b) of



See, e.g., IPR2021-00184, Ex. 1093 ¶¶ 19-20

## Herron's Non-Spherical MCC



Ex. 1016 (Herron) at Fig. 1(A)

pale yellow cubes. The structure consists of an 82-atom CdS core that is a roughly spherical piece of the cubic sphalerite lattice ~12 angstroms in diameter. The four corners of the

Ex. 1016 (Herron) at Abstract

- No dispute Herron discloses a MCC

Ex. 1099 (Dr. Cossairt Tr.) at 114:14-17; see also '423 patent, 11:56-67;'828 patent, 12:46; '365 patent, 12:9

## PO's arguments regarding size of nanorods are irrelevant and incorrect

- Evidence shows MCCs are not perfectly spherical
- Claims do not require that nanoparticles have same size



Dr. Cossairt  
PO's Expert

**Q** None of the claims of the '828 patent require the nanoparticles to be a specific size, correct?

**A** Correct.

Ex. 1099 at 98:3-6; see also *id.* at 86:9-11, 94:12-16, 101:14-15

7. A method in accordance with claim 1, wherein effecting conversion of the nanoparticle precursor composition comprises:

- a) monitoring an average size of the nanoparticles being grown; and
- b) terminating nanoparticle growth when the average nanoparticle size reaches a predetermined value.

'423 patent at cl. 7

- Evidence also shows size variation also due to other factors

### Banin

The rod-shaped nanocrystals prepared by the method of the invention possess diameters that depend on the diameter of the catalyst nanoparticles used in their growth. The diameter of the nanoparticles used in the method of the invention are typically in the range of between about 1 to about 50 nm. Further parameters that may affect the size and shape of the reaction products are, *inter alia*, the following: the type of the metal catalyst, the reaction temperature, duration of the reaction and concentration of precursors.

Ex. 1005 (Banin) at 7:6-12; see also Ex. 1099 at 64:6-17 (Dr. Cossairt admitting same)

## Whether Banin's gold MCCs agglomerate is irrelevant



Dr. Green  
Pet'r's Expert

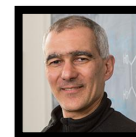
A POSITA would have understood that “agglomeration” is a physical rather than chemical act, and therefore each portion of the alleged “agglomeration” in Banin is still a well-defined  $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$  molecule that satisfies any proposed construction of MCC. Indeed, Banin does not state that its MCCs undergo any chemical change when they aggregate, and a POSITA would not have understood Banin to suggest such a chemical change. *See* Ex. 1005, 23:23-24:2. A POSITA thus would have understood that each of Banin's  $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$  clusters remain identical even if they physically aggregate. For example, a POSITA would have

IPR2021-00183, Ex. 1093 ¶ 27; IPR2021-00184, Ex. 1093 ¶ 27;  
IPR2021-00185, Ex. 1093 ¶ 27; IPR2021-00186, Ex. 1093 ¶ 27

1. A nanoparticle comprising a molecular cluster compound and a core semiconductor material disposed on the molecular cluster compound, wherein the semiconductor material comprises one or more elements not comprised within the molecular cluster compound.

'365 patent at cl. 1

## Dr. Bawendi's testimony does not support PO's aggregation arguments



Dr. Bawendi  
Dist. Ct. Expert

### PO's Response

nanoparticle patents.”). Here, Dr. Bawendi was discussing his own publication that showed indium phosphide “cluster mixtures with masses around 10 kDa.” Ex. 2033, 13470. Dr. Bawendi confirmed that clusters that have a distribution of masses, like the gold clusters in Banin and the clusters in his own article, are not MCCs under the Court’s construction of the term. Specifically, Dr. Bawendi testified:

IPR2021-00184, Paper 25 at 38; see also *id.* at 41

- Dr. Bawendi’s article and testimony did not concern Banin, Banin’s gold MCCs, or size distributions

MALDI spectra of the same InP growth mixtures not only provide information on the mass evolution of the larger particles but also reveal the existence of small cluster mixtures with masses around 10 kDa during the growth process. For the

Ex. 2033 at 2

A. These aggregates of indium and phosphorus that form --  
(Discussion off the record.)  
THE WITNESS: -- indium and phosphorus span  
a distribution of masses, and they don't have a  
molecular formula that's the same for all of them.

Ex. 2034 at 120:8-13

# Banin Discloses a MCC

## PO's argument that prior art was unable to chemically characterize the MCC is wrong and irrelevant

- No support
- Not required



**Dr. Green**  
Pet'r's Expert

disagree. A POSITA would not require chemical characterization data in order to conclude that the  $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$  clusters disclosed in Banin are well-defined chemical structures all possessing the same relative molecular formula. Indeed, Dr.

IPR2021-00183, Ex. 1093 ¶ 25; IPR2021-00184, Ex. 1093 ¶ 25;  
IPR2021-00185, Ex. 1093 ¶ 25; IPR2021-00186, Ex. 1093 ¶ 25



**Dr. Cossairt**  
PO's Expert

The nanoparticle patents give example of what they refer to as molecular cluster compounds; is that correct?

A Yes, that is correct.

Q But none of these patents provide any mass spectrometry data for molecular cluster compounds; is that correct?

A That's correct.

Q And they don't provide any X-ray diffraction data; is that right?

A That's correct, but it's not in the patents. But several of these molecular cluster compounds were well-known in the literature and have existing X-ray and other analytical characterization data that confirm their atomic connectivity in structures.

Ex. 1099 at 35:5-36:1

# Banin Discloses Conditions Permitting Seeding and Growth

## PO's argument that Banin teaches away from seeded growth is wrong



“First and foremost, teaching away is not relevant to an anticipation analysis; it is only a component of an obviousness analysis.”

*Krippelz v. Ford Motor Co.*, 667 F.3d 1261, 1269 (Fed. Cir. 2012)

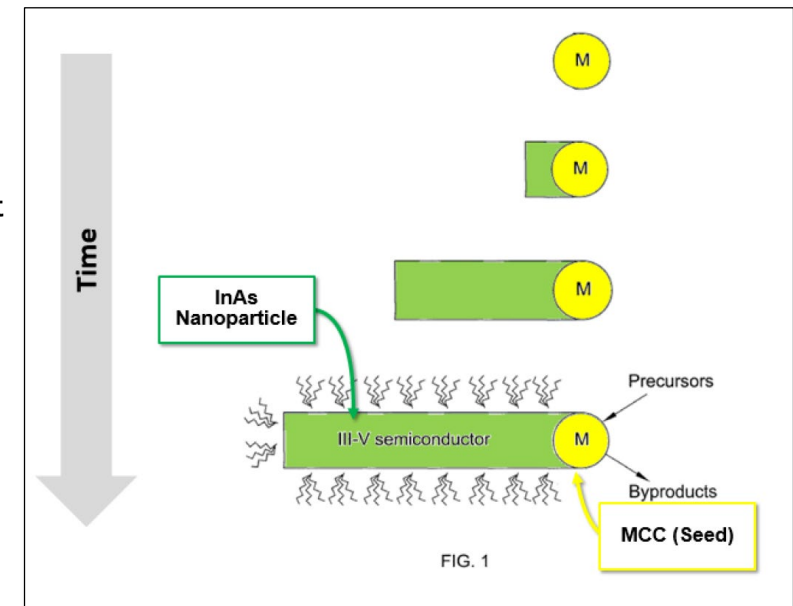
### Banin

The main idea of the present invention is based on introducing nanoparticles of a metal catalyst that serve as starting nanocrystals from which nanorods of inorganic semiconductors grow in solution while stopping the growth to obtain rods. Without being bound to theory, it is proposed that the reaction precursors dissolve in the metal nanoparticles and the semiconductor nanorods grow from these particles.

Ex. 1005 (Banin) at 6:3-8



Dr. Green  
Pet'r's Expert



IPR2021-00184, Ex. 1093 ¶ 34 (citing Ex. 1005, Fig. 1 (annotated))

# Banin Discloses Seeded Growth

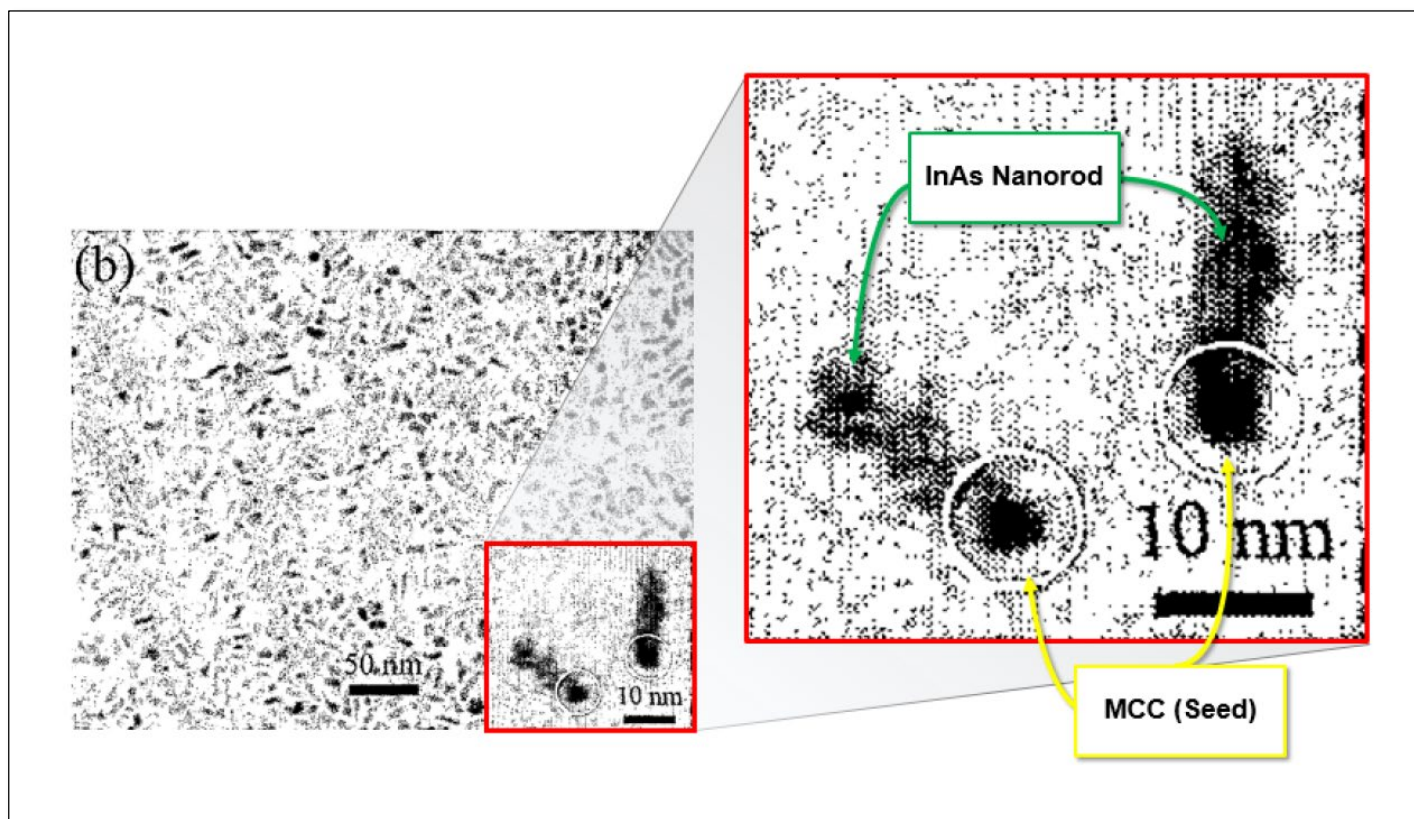
## Banin states that its gold seeds are at the end of the nanorods

The inset of Fig. 10B shows rods with gold particles on the end, demonstrating the SLS growth mechanism. The synthesis in this case yields InAs nanorods with

Ex. 1005 (Banin) at 22:29-30



Dr. Green  
Pet'r's Expert



IPR2021-00183, Ex. 1093 ¶ 35; IPR2021-00184, Ex. 1093 ¶ 34; IPR2021-00185, Ex. 1093 ¶ 35; IPR2021-00186, Ex. 1093 ¶ 36

- Summary of IPRs and Disputed Issues
- **Banin Grounds**
  - Anticipation
  - Obviousness
    - Alone
      - + Herron/Farneth, + Bawendi, + Treadway, + Braun
- **Zaban Grounds**
  - Obviousness
    - + Ptatschek/Farneth
    - + Yu, + Braun, + Bawendi

## Banin discloses MCCs and it would have been obvious to use MCCs

### Institution Decision

#### *E. Asserted Obviousness over Banin*

Petitioner asserts that the subject matter of claims 1, 7–12, 17, 22 and 23 would have been obvious over Banin. Pet. 14. For reasons explained above, we find Petitioner shows sufficiently that Banin anticipates those claims. Because anticipation is “the epitome of obviousness,” *In re Kalm*, 378 F.2d 959, 962 (CCPA 1967), Petitioner’s showing with respect to anticipation by Banin likely is also sufficient with respect to obviousness over Banin, at this stage, given the absence of record evidence of objective indicia of nonobviousness. Patent Owner asserts no other arguments as to

IPR2021-00186, Paper 17 at 22



Dr. Cossairt  
PO's Expert

**Q** Is it fair to say that prior 2004, a person of ordinary skill in the art would have desired their nanoparticles to be as close to identical size as possible?

**A** That was certainly a big goal in the field at that time, and it remains for many of us today.

Ex. 1099 at 67:3-10

**Q** Why is it important that each molecular cluster compound must be identical?

**A** That's a very interesting question. It depends -- so it depends on how they are being used and the goal of the synthesis. So if the goal of the synthesis is to make various sized uniform nanoparticles, then you would want your seeds to be identical.

**Q** And that was known in the 2004 timeframe, right?

**A** Yes. It was understood that using more size-uniform seeds would be expected to result in more size-uniform products, yes.

Ex. 1099 at 49:20-50:13

# Banin Renders Obvious Claim 4

## PO's argument confuses Banin's stock and growth solutions

### '423 Patent – Claim 4

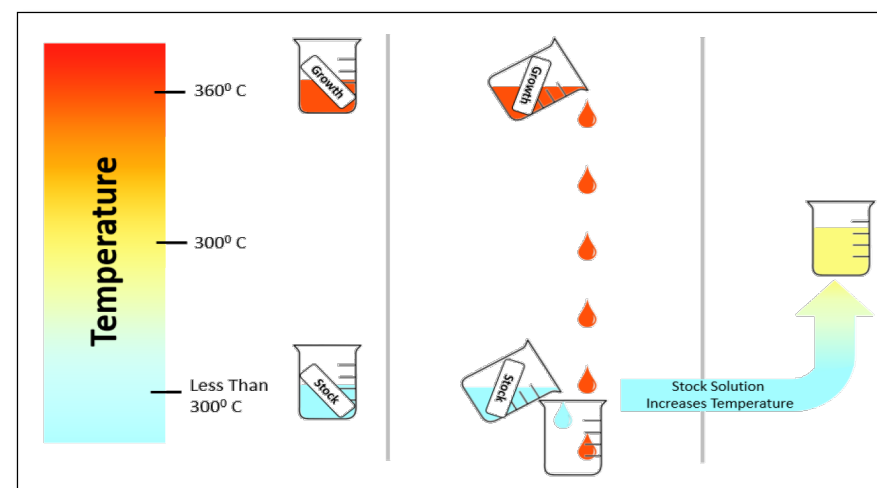
4. A method in accordance with claim 1, wherein the molecular cluster compound and nanoparticle precursor composition are dissolved in a solvent at a first temperature to form a solution and a temperature of the solution is then increased to a second temperature sufficient to initiate seeding and growth of the nanoparticles on the molecular clusters of said compound.

'423 patent, cl. 4

### Banin

synthesized by the published procedures [24]. InAs rods were prepared as follows: a 4-neck flask was used, with 2 g TOPO as the growth solution. The stock solution contained 100 mg (0.34 mmol)  $(\text{TMS})_3\text{As}$ , 0.57 g (0.68 mmol)  $\text{InCl}_3/\text{TOP}$  solution (0.3 g/ml), and 0.5 g gold/toluene solution (13.8 mg/g) in 1 g TOP. The growth solution was heated to 360 °C. The stock solution was then injected into the growth solution within 0.1 s under vigorous stirring, leading to the decrease of the reaction temperature to about 300 °C. A few seconds later, 2 g cold TOP was injected to further quench the temperature to about 220 °C and following, the reaction was cooled to room temperature. The rods were purified

Ex. 1005 (Banin) at 20:16-24



IPR2021-00184, Ex. 1093 ¶ 37

# Banin Renders Obvious Claims 5 and 6

## Banin renders obvious the claimed first and second temperatures

### '423 Patent – Claims 5 & 6

5. A method in accordance with claim 4, wherein the first temperature is selected from a range of 50° C. to 100° C.

6. A method in accordance with claim 4, wherein the second temperature is selected from a range of 120° C. to 280° C.

### PO's Response

from a range of 120° C. to 280° C.” Ex. 1001, 20:24-28. Claim 5 and 6 are not obvious because Banin expressly states that its method does not work at temperatures lower than 300 ° C. Ex. 1005, 19 (“It was found by the inventors that syntheses at a lower reaction temperature of 300 °C, does not yield one-dimensional growth . . .”); Ex. 2030 ¶130. Thus, a reaction temperature of 50 °C to 100 °C would simply not work, nor would a second reaction temperature of 120 °C to 280 °C. Ex. 2030 ¶130.

IPR2021-00184, Paper 25 at 45-46

- PO mischaracterizes Banin’s disclosure and the challenged claims
  - Obvious to adjust temperatures — higher first temperature improves dissolution rate and lower second temperature is encompassed within Banin’s disclosure of “*about* 300° C”
  - PO’s cites a different embodiment of Banin (Ex. 1005 at 17:22-19:12) involving Au nanoparticles with 2 nm diameter
  - Banin does not say temperatures below 300° C do not work, only that 1D growth did not occur for that different embodiment (*Id.* at 19:9-12)
  - PO’s expert admits challenged claims do not require any specific nanoparticle shape
  - Claim 5 does not recite a reaction temperature, but rather a pre-reaction solution temperature

See Dr. Green’s 1<sup>st</sup> Decl., IPR2021-00184, Ex. 1002 ¶¶ 123-27;  
Dr. Green’s 2<sup>nd</sup> Decl., IPR2021-00184, Ex. 1093 ¶ 38

- Summary of IPRs and Disputed Issues
- **Banin Grounds**
  - Anticipation
  - Obviousness
    - Alone
    - + Herron/Farneth, + Bawendi, + Treadway, + Braun
- Zaban Grounds
  - Obviousness
    - + Ptatschek/Farneth
    - + Yu, + Braun, + Bawendi

# Banin Grounds: Banin and Herron or Farneth Render Obvious

## Banin in view of Herron ('365 patent, cls. 2-6, 18-21; '828 patent, cls. 1, 3-6, 8-14) or Farneth ('828 patent, cls. 1, 3) renders obvious

**Banin:** Discloses method of making nanoparticles in presence of  $\text{Au}_{101}$  MCC, which may be replaced with Cd- and Zn-based compounds, under conditions permitting seeding and growth

**Herron:** Discloses Cd-based MCC

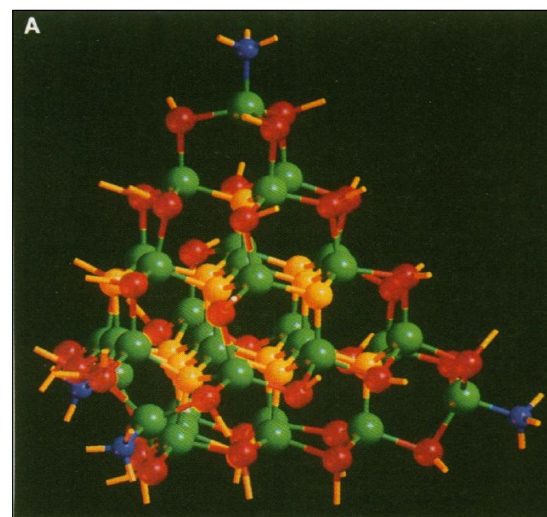
**Farneth:** Discloses Zn-based MCC

**Petition:** A POSITA would have been motivated to use Herron's or Farneth's MCC in Banin's process because:

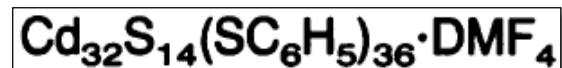
- Group 12 MCCs were less expensive than Au MCCs,
- Group 12 MCCs were known and used in the field, and
- Banin teaches using Zn/Cd-based compounds as seeds

**PO Disputes:** Motivation to combine Banin with Herron or Farneth

Herron

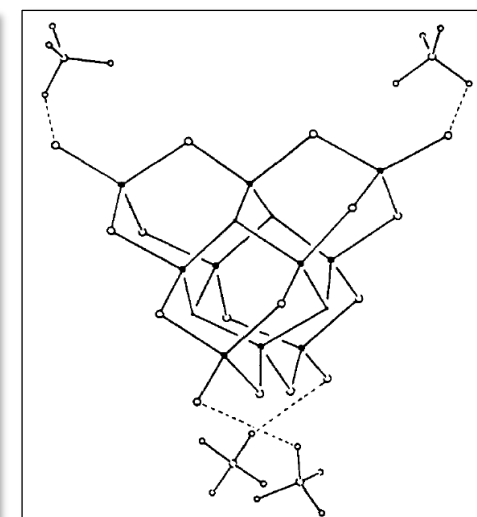


Ex. 1016 (Herron) at 1427, Fig. 1

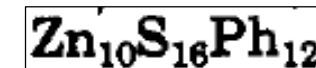


Ex. 1016 at Abstract

Farneth



Ex. 1009 (Farneth) at 919, Fig. 5

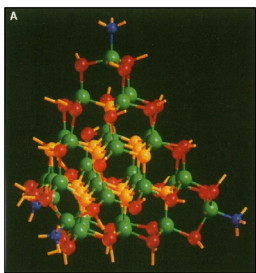


Ex. 1009 at 919

# Banin Grounds: Overview of Herron and Farneth

## Herron and Farneth disclose MCCs useful for semiconductor films

### Herron



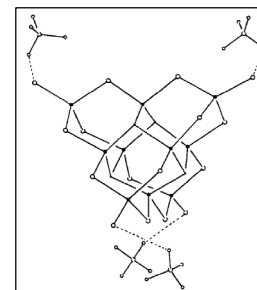
**Crystal Structure and Optical Properties of  $\text{Cd}_{32}\text{S}_{14}(\text{SC}_6\text{H}_5)_{36}\cdot\text{DMF}_{41}$ , a Cluster with a 15 Angstrom CdS Core**

Ex. 1016 (Herron) at Title

Finally, the solubility of this new crystalline cluster may be used in the production of polymer films, such as polyvinylcarbazole, doped with the CdS cluster simply by spin-coating from a pyridine solution. Such films have been found to exhibit good photoconductive properties (10), which points to a real utility for such soluble semiconductor clusters in the preparation of materials that go into electronic devices made for this and other thin-film applications.

Ex. 1016 (Herron) at 1428

### Farneth



**$\text{Zn}_{10}\text{S}_{16}\text{Ph}_{12}$**

Ex. 1009 (Farneth) at 919

physical properties from the starting material. One of the technological advantages that these surface passivated molecular clusters promise is their processability. They can be thought of, for example, as soluble reagents that are precursors to semiconductor films. Therefore, the

Ex. 1009 (Farneth) at 921



## PO's no motivation and hindsight arguments ignore known benefits of MCCs

- Prior art taught benefits of MCCs
  - greater synthetic control
  - lower reaction temperatures
  - improved nanoparticle properties
  - better reaction scalability

### Cumberland

chalcogenide semiconductor lattice.<sup>53,71</sup> The application of molecular inorganic precursors offers a unique opportunity for growth of nanomaterials at lower temperatures by providing intact nuclei in HDA for the formation of CdSe nanocrystals. The precursor,  $(\text{Li})_4\text{[Cd}_{10}\text{Se}_4(\text{SPh})_{16}]$ , can be envisioned as a fragment of the bulk structure that acts as an effective molecular template for growth.<sup>41,42,49</sup> Controlled growth of nanoc-

Ex. 1045 (Cumberland) at 1584

### Khitrov

methodology is the attainment of greater synthetic control. The use of a cluster based single source precursor allows nanomaterial growth to be initiated at low temperature without a requisite pyrolytic step for nucleus formation traditionally required for lyothermal growth processes. The elimination of the pyrolytic step allows greater synthetic control, slow thermodynamic growth at lower temperatures, high crystallinity, and reaction scalability.

Ex. 1069 (Khitrov) at 44

## PO's expert admitted MCCs known and provided benefits

### MCCs known, including Cd-based MCCs



Dr. Cossairt  
PO's Expert

Q Sure.  
Methods of making nanoparticles using molecular cluster compounds were known prior to 2004; is that correct?

A Yes. In general, that's correct.

Q For example, it was known that you could use a cadmium-based molecular cluster compound to make nanoparticles, correct?

A There were examples of using cadmium-based clusters to make nanoparticles, yes.

Q And in your previous answer, when you used the word "clusters," you meant molecular cluster compounds, correct?

A Correct.

Ex. 1099 at 79:3-19

### Motive to use for known benefits

Q Why is it important that each molecular cluster compound must be identical?

A That's a very interesting question. It depends -- so it depends on how they are being used and the goal of the synthesis. So if the goal of the synthesis is to make various sized uniform nanoparticles, then you would want your seeds to be identical.

Q And that was known in the 2004 timeframe, right?

A Yes. It was understood that using more size-uniform seeds would be expected to result in more size-uniform products, yes.

\* \* \*

Q Would a person of ordinary skill in the art have known that using molecular cluster compounds could allow you to use a lower reaction temperature?

A A person of ordinary skill in the art would understand that using a seed, in general, would be expected to allow you to use a lower reaction temperature.

Ex. 1099 at 49:20-50:7, 81:17-82:3

Q Why would a person of ordinary skill in the art have wanted to use a molecular cluster compound to make nanoparticles?

MR. NEWMAN: Objection.

THE WITNESS: I think there are many possibilities and it would be hard to, you know, come up with all the -- all of them.

BY MR. WILSON:

Q Can you provide an example?

MR. NEWMAN: Same objection.

THE WITNESS: We talked about this earlier, as well, where -- I will give one example -- that using a molecular cluster compound where every cluster is the same would have benefits in terms of having very uniform seeds that would grow more uniform nanocrystals via, you know, a specific mechanism.

But there's lots of different possible mechanisms for applying these cluster compounds, so there's lots of different answers that you could come up with from this.

Ex. 1099 at 80:10-81:15

# Banin and Herron or Farneth Render Obvious

## PO's metal vs. semiconductor argument is inapt

- No support



Dr. Cossairt  
PO's Expert

137. A POSITA would not have been motivated to replace the metal catalysts disclosed in Banin with a semiconductor material disclosed in Herron. Semiconductors are not the same as metals. *See* Ex. 2031 (Green Depo.) at 18:13-15. Moreover, Herron does not disclose any melting point for the modified CdS

IPR2021-00186, Ex. 2030 ¶ 137; *see also* IPR2021-00183, Ex. 2030 ¶ 131



Dr. Green  
Pet'r's Expert

13 Q What is the difference between a  
14 semiconductor and a metal?  
15 A It's the electronic structure.  
16 Q What about the electronic structure  
17 is different?  
18 A A semiconductor has a band gap.  
19 Q So metals have no band gap.  
20 Is that right?  
21 A In the bulk, that's correct.  
22 Q What do you mean by "in the bulk"?  
23 A When they're not nanomaterials.

Ex. 2031 at 18:13-23

- Banin's express disclosure

The metal catalyst can be made, for example, of a transition metal, e.g. Zn, Cd, Mn, etc., a Group IIIa metal, e.g. In, Ga, Al, alloys of such metals such as for example Au-In, or core/shell layered metal particle. More specific examples of

Ex. 1005 (Banin) at 6:9-11

30. The method according to Claim 24, wherein said metal catalyst is selected from Fe, Zn, Pd, Pt, Ni, Co, Mn, Ag, Cd or alloys and layered particles thereof.

Ex. 1005 (Banin) at 31:3-4

# Banin and Herron or Farneth Render Obvious

## PO's metal vs. semiconductor argument is inapt

- Evidence shows semiconductors were used to grow nanoparticles before the priority date



**Dr. Green**  
Pet's Expert

by Banin. *See* POR 47-50, 53, 54-57. I disagree. To begin, PO does not cite (and I am not aware of) a single instance in which a POSITA tried and failed to use a semiconductor as a catalyst in SLS-nanorod synthesis. Additionally, based on the prior art, a POSITA would have had a reasonable expectation of success that semiconductors could be used in Banin's process, including because semiconductor seeds had successfully melted and seeded growth of nanoparticles in related vapor-liquid-solid ("VLS") nanoparticle synthesis. *See* Ex. 1098, 274 (employing the semiconductor germanium ("Ge") in VLS growth); Ex. 2030 ¶46 (recognizing VLS involves melting a liquid catalyst and dissolving precursors). For example, Zheng

IPR2021-00183, Ex. 1093 ¶ 38; IPR2021-00186, Ex. 1093 ¶ 40



**Dr. Cossairt**  
PO's Expert

47. The Solution-Liquid-Solid ("SLS") method is related and analogous to VLS in that it also uses molten metal to dissolve precursors and drive one dimensional nanoparticle growth. SLS differs however in that it (1) is typically

IPR2021-00183, Ex. 2030 ¶ 47; IPR2021-00186, Ex. 2030 ¶ 51

### Pan

We report here that Ge, a Group IV semiconductor, can be used as an efficient catalyst for high-yield growth of very long (up to several hundred micrometers), extremely straight, and quasi-aligned arrays of single-crystalline ZnO nanowires in a VLS process. The Zn source was generated by carbo-

Ex. 1098 (Pan) at 274

# Banin and Herron or Farneth Render Obvious

## PO's melting point argument is incorrect

- PO's argument that the MCCs will not melt is wrong

15. Moreover, Herron does not disclose any melting point for the modified CdS semiconductor cluster. **Bulk CdS will not melt until it reaches approximately 1480 °C.** See Ex. 2043 at 5. And Herron's cluster was derived from a material that would

IPR2021-00186, Ex. 2030 ¶ 137



**Dr. Cossairt**  
PO's Expert

**Q But even though the melting point of gold -- and I will represent to you is above 800 degrees celsius -- Banin teaches that its gold cluster still worked to grow nanoparticles at a much lower temperature; is that correct?**

**A** It's very well-understood that nano materials have unique properties relative to bulk materials, and they have this dependence in their physical properties, melting properties for example, based on size.

Ex. 1099 at 127:4-15; see also Ex. 1005 (Banin) at 19:6-9



**Dr. Green**  
Pet's Expert

40. Additionally, it is my opinion that PO's arguments regarding the melting point of the MCCs disclosed in Herron and Farneth are irrelevant at least because **Yu explains that un-melted clusters can seed growth of nanoparticles.** See Ex. 1010, 9198 (explaining that, even at room temperature, "preformed seeds provide the nuclei for subsequent growth of metallic nanoparticles"); Ex. 1002 ¶¶55-56, 92-98, 155-61.

IPR2021-00183, Ex. 1093 ¶ 40; IPR2021-00186, Ex. 1093 ¶ 42



**Dr. Cossairt**  
PO's Expert

Yu teaches using Hutchison's gold clusters to make metal nanoparticles at **low temperatures.** See Ex. 1002 (Green Decl.) at ¶ 160 (Yu teaches "sufficiently low temperatures" ... "ranging from room temperature to 150 °C."). Such temperatures are so low that the gold particles remain solid in solution and can act as seeds. See generally, Ex. 1010.

IPR2021-00186, Ex. 2030 ¶ 141

- A POSITA would have reasonably expected the MCCs to seed growth

# Banin and Farneth Render Obvious

## Contrary to PO's argument, a POSITA would not have been deterred from using Farneth's "Wurtzite" MCC in Banin's process

- PO misreads Banin
  - Does not say Farneth's MCC would not work
  - Does not say its process does not work with wurtzite nanocrystals
  - It only says in a "recent example," that example found "shape control" "not easily applicable"
- Challenged claims are not limited to a specific nanoparticle shape



Dr. Cossairt  
PO's Expert

light-emitting diodes [11, 15]. A recent example of rod-shaped nanocrystals was described in relation with CdSe nanocrystals [16, 17]. Shape control in this case was realized by kinetically controlled growth along the special c-axis of wurtzite CdSe nanocrystals through the use of a mixture of surfactants. Such a process is not easily applicable for the growth of cubic-structured semiconductor nanorods, e.g. nanorods of a few important III-V semiconductors. Therefore a novel and completely different rod growth mechanism is needed for these compounds.

Ex. 1005 (Banin) at 4:24-30

**Q** All right. And once again, none of the claims of the '828 patent require the nanoparticles to be of any specific shape, correct?

**A** Correct.

Ex. 1099 at 97:20-98:6

# Banin Grounds: Banin and Bawendi Render Obvious

## Banin in view of Bawendi renders obvious ('423 patent, cls. 7-9)

**Banin:** Discloses method of making nanoparticles in the presence of Au<sub>101</sub> MCC, under conditions permitting seeding and growth

**Bawendi:** Teaches technique for monitoring the size of a growing nanoparticle in solution

**Petition:** A POSITA would have been motivated to use Bawendi's size-monitoring technique with Banin's method to better control nanoparticle size

**PO Disputes:** Motivation to combine Banin with Bawendi

### Bawendi

The method can include monitoring the size distribution of a population including of the nanocrystallite, lowering the temperature of the mixture in response to a spreading of the size distribution, or increasing the temperature of the mixture in response to when monitoring indicates growth appears to stop. The method can also include exposing the nanocrystallite to a compound having affinity for a surface of the nanocrystallite.

Ex. 1014 (Bawendi) at 2:45-52

## A POSITA would have been motivated to use Bawendi's size-monitoring technique in Banin's process

### '423 Patent – Claims 7-9

7. A method in accordance with claim 1, wherein effecting conversion of the nanoparticle precursor composition comprises:

- a) monitoring an average size of the nanoparticles being grown; and
- b) terminating nanoparticle growth when the average nanoparticle size reaches a predetermined value.

'423 patent at claim 7; see also *id.* at claims 8, 9



Dr. Green  
Pet's Expert

139. It is my opinion that a POSITA would have been motivated to add the average-size-monitoring technique taught in Bawendi to the nanoparticle synthesis method disclosed in Banin in order to improve control over the size of the nanoparticle. Further, it is my opinion that a POSITA would have understood that

IPR2021-00184, Ex. 1002 ¶ 139

### Bawendi

Size distribution during the growth stage of the reaction can be estimated by monitoring the absorption line widths of the particles. Modification of the reaction temperature in response to changes in the absorption spectrum of the particles allows the maintenance of a sharp particle size distribution during growth. Reactants can be added to the nucleation solution during crystal growth to grow larger crystals. By stopping growth at a particular nanocrystallite average diameter and choosing the proper composition of the semiconducting material, the emission spectra of the nanocrystallites can be tuned continuously over the wavelength range of 400 nm to 800 nm. The nanocrystallite has

Ex. 1014 (Bawendi) at 4:59-5:3; see also *id.* at 4:66-5:3, 6:67-7:2 (terminating growth by reducing temperature)

# Banin and Bawendi Render Obvious

## Contrary to PO's argument, Bawendi's measurement of a "diameter" does not alter the motivation to combine

- Bawendi states its method applies to nanorods and uses "diameter" to refer to nanoparticle size

The invention features methods of manufacturing a nanocrystallite. The nanocrystallite has a diameter of less than 150 Å. The nanocrystallite can be a member of a population of nanocrystallites having a narrow size distribution. The nanocrystallite can be a sphere, rod, disk, or other shape. The nanocrystallite can include a core of a

Ex. 1014 (Bawendi) at 1:36-41

nanocrystallite is a member of a population of nanocrystallites. As a result of the discrete nucleation and controlled growth, the population of nanocrystallites obtained has a narrow, monodisperse distribution of diameters. The monodisperse distribution of diameters can also be referred to as a size. The

Ex. 1014 (Bawendi) at 3:10-14

- "Diameter" refers to overall nanoparticle size, not just the short dimension of nanorod

**di•am•e•ter** |dī'æmītər| (abbr.: diam.) ▶n. 1 a straight line passing from side to side through the center of a body or figure, esp. a circle or sphere. See illustration at GEOMETRIC.  
■ the length of this line. ■ a transverse measurement of something; width or thickness.

Ex. 1095 (New Oxford American Dictionary) at 3

## PO's new sur-reply arguments are waived, unsupported, and wrong

- No purported reason to use Bawendi's size-monitoring technique when Banin discloses size selection "*after* the reaction"
  - Unsupported and ignores two different, complementary techniques
  - Further, ignores known and predictable option
- Banin's reaction "takes place in a few seconds," with no time for size monitoring
  - Banin does not state nanorods fully grown and reaction ends after quenching

### Banin

the decrease of the reaction temperature to about 300 °C. A few seconds later, 2 g cold TOP was injected to further quench the temperature to about 220 °C and following, the reaction was cooled to room temperature. The rods were purified

Ex. 1005 (Banin) at 20:22-24



Dr. Green  
Pet's Expert

41. PO then turns to arguing that a POSITA would have been discouraged from using the size-monitoring technique disclosed in Bawendi with Banin's process. POR 46-48. I disagree. The size-monitoring technique disclosed in Bawendi involves extracting a small aliquot of the growth solution and observing absorption spectra over time to monitor the nanoparticle size, and as a result could be used with most methods of making nanoparticles, including the process disclosed in Banin. Ex. 1014, 4:59-5:19; Ex. 1002 ¶ 140; see Ex. 1037, 34 (linking absorption spectra with nanoparticle size); Ex. 1038, 215-16 (same); Ex. 1039, 65-66 (same). PO does not provide any evidence to the contrary, nor does Dr. Cossairt.

IPR2021-00184, Ex. 1002 ¶ 142

# Banin Grounds: Banin and Treadway Render Obvious

## Banin in view of Treadway renders obvious ('365 patent, cls. 13, 14)

**Banin:** Discloses method of making nanoparticles in the presence of Au<sub>101</sub> MCC, under conditions permitting seeding and growth

**Treadway:** Discloses nanoparticles having ternary and quaternary shell semiconductor materials

**Petition:** A POSITA would have been motivated to combine Banin and Treadway because it was known that tuning the composition of the shell material could achieve desired optical and electronic nanoparticle properties

**PO Disputes:** Motivation to combine Banin with Treadway

### Treadway

The inorganic shell may be comprised of (a) a first element selected from Groups 2, 12, 13 or 14 of the Periodic Table of the Elements and a second element selected from Group 16 of the Periodic Table of the Elements, (b) a first element selected from Group 13 of the Periodic Table of the Elements and a second element selected from Group 15 of the Periodic Table of the Elements, or (c) a Group 14 element. Suitable second materials include, but are not limited to, MgO, MgS, MgSe, MgTe, CaO, CaS, CaSe, CaTe, SrO, SrS, SrSe, SrTe, BaO, BaS, BaSe, BaTe, ZnO, ZnS, ZnSe, ZnTe, CdO, CdS, CdSe, CdTe, HgO, HgS, Al<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>S<sub>3</sub>, Al<sub>2</sub>Se<sub>3</sub>, Al<sub>2</sub>Te<sub>3</sub>, Ga<sub>2</sub>O<sub>3</sub>, Ga<sub>2</sub>S<sub>3</sub>, Ga<sub>2</sub>Se<sub>3</sub>, Ga<sub>2</sub>Te<sub>3</sub>, In<sub>2</sub>O<sub>3</sub>, In<sub>2</sub>S<sub>3</sub>, In<sub>2</sub>Se<sub>3</sub>, In<sub>2</sub>Te<sub>3</sub>, SiO<sub>2</sub>, GeO<sub>2</sub>, SnO, SnO<sub>2</sub>, SnS, SnSe, SnTe, PbO, PbO<sub>2</sub>, PbS, PbSe, PbTe, AlN, AlP, AlAs, AlSb, GaN, GaP, GaAs, GaSb, InN, BP, and ternary and quaternary mixtures and solid solutions thereof. Preferred second materials are CdSe, CdS, ZnSe, ZnS, CdO, ZnO, SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, and ZnTe. Optionally, an organic or other overcoat that is selected to provide compatibility with a dispersion medium may surround the shell.

Ex. 1015 (Treadway) at 3:58-4:10

# Banin and Treadway Render Obvious

## A POSITA would have been motivated to use Treadway's ternary and quaternary materials to improve the properties of Banin's InAs nanorods

- Adjusting shell material, such as the number of elements in the shell material, was known to tailor electronic nanoparticle properties

### Banin Book Chapter

nanocrystal [32–38]. In such composite core–shell structures, the shell type and shell thickness provide further control for tailoring the optical, electronic, electrical, and chemical properties of semiconductor nanocrystals.

Ex. 1059 (Banin Book Chapter) at 316

### Nanoparticles: From Theory to Application

The broad spectral coverage for luminescence from the ultraviolet to the near infrared offered via tunability of composition, size and shape in semiconductor nanocrystals presents an obvious advantage for using such materials as tunable optical gain media and in laser applications. Furthermore, low lasing thresholds

Ex. 1037 (Nanoparticles: From Theory to Application) at 320



Dr. Green  
Pet's Expert

Claims of Ground 4 are product, not process, claims. Additionally, as I explained in my original declaration, the prior art taught that “ternary and quaternary nanoparticles have better stability and photoluminescence durability properties than traditional core/shell nanoparticles,” which would have motivated a POSITA to combine Banin and Treadway. Ex. 1002 ¶¶149-51; Ex. 1037, 320; Ex. 1049, 15; Ex. 1056, Abstract, 12155; Ex. 1059, 316. Dr. Cossairt testified consistent with my opinion, admitting that ternary and quaternary nanoparticle materials had the known benefit of allowing greater control over nanoparticle optical and electronic properties. *See* Ex. 1099, 59:19-62:6.

IPR2021-00186, Ex. 1093 ¶¶ 49

# Banin and Braun Render Obvious

## Banin in view of Braun renders obvious ('557 patent, all challenged claims)

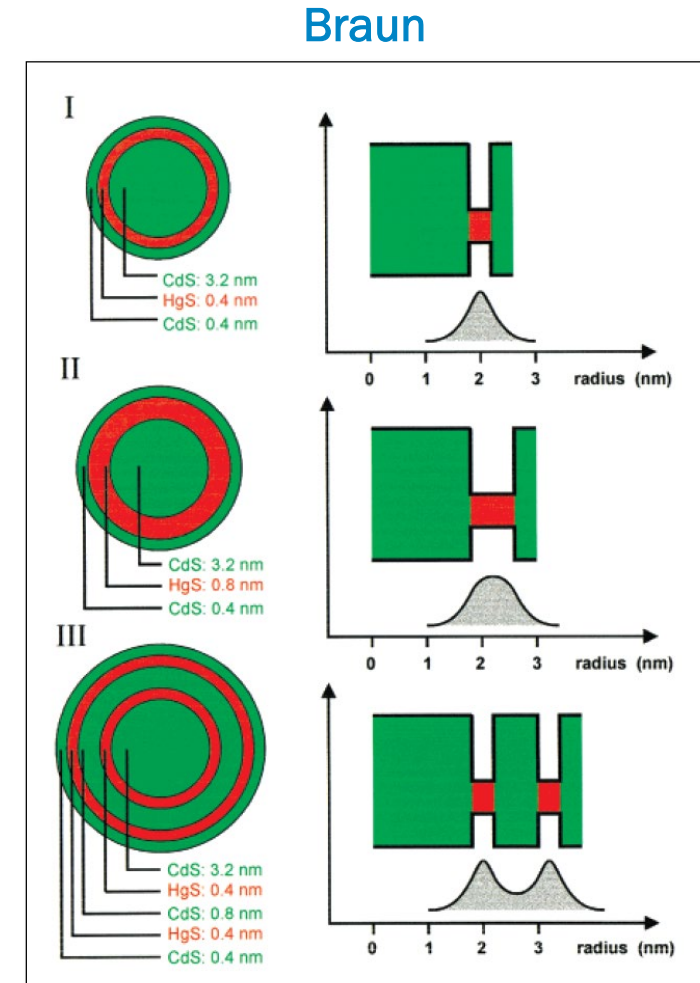
**Banin:** Discloses method of making nanoparticles in the presence of an Au<sub>101</sub> MCC, under conditions permitting seeding and growth

**Braun:** Discloses a multi-shell nanoparticle structure

**Petition:** A POSITA would have been motivated to combine Banin and Braun because

- MCCs were known and provided known benefits, and
- it was known multiple shells can improve nanoparticle optical properties

**PO Disputes:** (1) Combination discloses a MCC; (2) Motivation to combine Banin with Braun



Ex. 1013 (Braun) at 5549, Fig. 1

# Banin and Braun Render Obvious

## A POSITA would have been motivated to combine Banin and Braun, and PO's arguments to the contrary mischaracterize the combination

### Banin

Rod/shell nanocrystals based on InAs nanorods, e.g. InAs/ZnSe or InAs/CdSe, may be prepared to improve the photoluminescence quantum yield and to provide further control of the optical and electronic properties of the nanorods [19, 20].

Ex. 1005 (Banin) at 25:12-15



**Dr. Green**  
Pet'r's Expert

optical and electrical properties of the nanorods.” *Id.*, 25:12-15. Thus it is my opinion that a POSITA would have known from Banin’s disclosure that a shell could improve the optical characteristics of the nanoparticle. In addition, as explained in §IV.C, I opine that a POSITA would have understood that multi-shell nanoparticles, either with added carrier confinement at the core or with a QDQW structure, have improved optical properties because their structure provides enhanced quantum confinement. Ex. 1037, 68-69.

IPR2021-00185, Ex. 1002 ¶ 90; see also *id.* ¶¶ 49, 51-52



**Dr. Cossairt**  
PO's Expert

**Q** And in 2004 -- or by 2004, it was known that you could add more than one shell layer to a nanoparticle, correct?

**A** That's correct.

**Q** These were known as core multi-shell nanoparticles; is that right?

**A** Yeah, or sometimes core-shell shell.

Ex. 1099 at 51:7-15

- Summary of IPRs and Disputed Issues
- **Banin Grounds**
  - Anticipation
  - Obviousness
    - Alone
    - + Herron/Farneth, + Bawendi, + Treadway, + Braun
- **Zaban Grounds**
  - Obviousness
    - + Ptatschek/Farneth
    - + Yu, + Braun, + Bawendi

## Summary of Zaban Obviousness Combinations

### Zaban + Ptatschek

('423 patent, cls. 1, 10-16, 21-24)

**Petition:** a POSITA would have been motivated to replace Zaban's zinc-based precursor with Ptatschek's zinc-based MCC

**+ Yu** ('423 patent, cls. 4-6, 25)

**Petition:** perform Zaban's process at Yu's reaction temperatures

**+ Braun** ('557 patent, cls. 1, 16-17, cls. 4-6 with Yu)

**Petition:** create Braun's multi-shell nanoparticle structure using Zaban's process

**+ Bawendi** ('423 patent, cls. 7-9)

**Petition:** use Bawendi's nanoparticle size-monitoring technique in Zaban's process

### Zaban + Farneth + Yu

('365 patent, cls. 1-9, 17-23; '828 patent, cls. 1, 3-6, 14)

**Petition:** a POSITA would have been motivated to replace Zaban's zinc-based precursor with Ptatschek's or Farneth's zinc-based MCC at Yu's reaction temperatures

**+ Braun** ('828 patent, cls. 8-13)

**Petition:** create Braun's multi-shell nanoparticle structure using Zaban's process

### PO Disputes:

- 1) Motivation to combine Zaban with Ptatschek or Farneth
- 2) Motivation to add Yu
- 3) Motivation to add Braun

## A POSITA would have been motivated to replace Zaban's zinc-based precursor with Ptatschek's or Farneth's zinc-based MCC

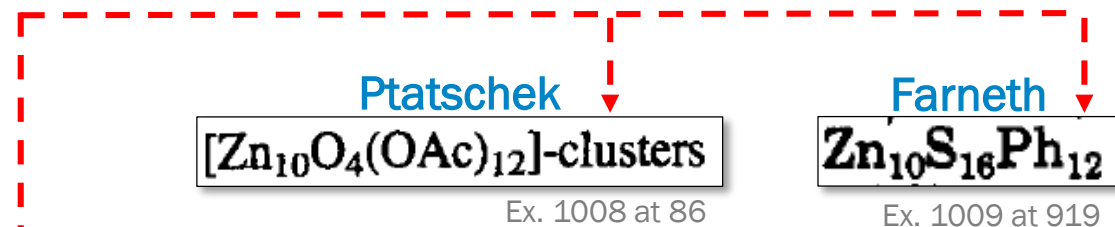
### Zaban

**Synthesis of Colloidal InP QDs.** Colloidal InP QDs were synthesized by colloidal chemistry methods using indium oxalate and tris(trimethylsilyl)phosphine ( $\text{P}(\text{SiMe}_3)_3$ ) as starting reactants; the reactants are heated for 3 days at 260–280 °C in the presence of trioctylphosphine oxide (TOPO) and trioctylphosphine (TOP). Details of the preparation are given in ref 14. During the synthesis, the QDs are capped with TOPO/TOP, which produce a compact hydrophobic shell on the QD surface.<sup>15</sup> p-Type (InP:Zn), n-type (InP:S), and undoped QDs of InP were synthesized as well-crystallized zinc blende nanocrystals. For synthesis of p-type InP QDs, indium oxalate was mixed with zinc acetate in a ratio such that the resulting QDs contain on average one  $\text{Zn}^{2+}$  ion per particle. For example, for 40-Å QDs, the ratio In:Zn is  $10^3:1$ . For n-type InP QDs,  $\text{P}(\text{SiMe}_3)_3$  was mixed with (bis-

Ex. 1006 (Zaban) at 3154

recombination of injected electrons with  $\text{I}_3^-$ . We found that p-type InP/TiO<sub>2</sub> electrodes are stable during illumination while n-type InP/TiO<sub>2</sub> electrodes photocorrode in the electrochemical cell. The reason for this behavior is not understood. Perhaps the p-type InP produces

Ex. 1006 (Zaban) at 3156



- PO's expert admits Farneth discloses zinc-based MCC and does not dispute Ptatschek does as well



**Dr. Cossairt**  
PO's Expert

And you also don't dispute that Farneth discloses a molecular cluster compound, right?

A That's correct.

Ex. 1099 at 115:2-5

## A POSITA had reasons to replace Zaban’s zinc “dopant” precursor with Ptatschek’s or Farneth’s zinc-based MCC

- Proposed combination provides (1) zinc in Zaban’s InP QDs and (2) MCC benefits



Dr. Green  
Pet’r’s Expert

reaction temperatures was known. Ex. 1099, 79:3-7, 80:10-82:3. As a result, replacing the zinc-based precursor disclosed in Zaban with a zinc-based MCC would have allowed a POSITA to achieve Zaban’s goal of incorporating zinc into InP QDs, while simultaneously obtaining the numerous known benefits of seeded growth using MCCs. Ex. 1002 ¶¶157-59, 187-89; see also Ex. 1096, Abstract, 7841-43 (using zinc-based MCCs in order to improve nanoparticle optical properties).

properties” POR 50-51. I disagree. A POSITA would have understood that the zinc-based MCC disclosed in Ptatschek would act as a nucleation point upon which the InP QD core of Zaban’s QDs forms, meaning the zinc-based MCC of Ptatschek improves the electrical properties of the core by incorporating zinc into the QD material without itself being part of the core material (similar to a dopant). See Ex. 1008, Abstract, 85-86; Ex. 1010, 9198; Ex. 1002 ¶¶55-56, 155-57; Ex. 1096, Abstract, 7843. It is my opinion that a POSITA would have recognized that using

IPR2021-00184, Ex. 1093 ¶¶ 44, 50; IPR2021-00185, Ex. 1093 ¶¶ 41, 47; see also IPR2021-00183, Ex. 1093 ¶¶ 53, 59; IPR2021-00186, Ex. 1093 ¶¶ 52, 58

- In 1999, Leeb disclosed adding zinc-based MCCs to nanoparticle films to improve electronic properties

**TABLE 2: Effect of Infiltration on the Electroluminescence Characteristics of Nanoporous ITO/Mn:ZnS/Al and ITO/Mn:CdZnS/Al Test Components**

active EL region	infiltrated species	luminance (cd/m <sup>2</sup> )	EL efficiency (10 <sup>-3</sup> %)
TBP–Mn:ZnS	none	0.1	0.001
	(Zn <sub>4</sub> O)OAc <sub>6</sub> , (Zn <sub>10</sub> O <sub>4</sub> )OAc <sub>12</sub>	1	0.0014
	TBP–ZnCl <sub>2</sub>	1	0.002
TBP–Mn/CdZnS	TBP–ZnI <sub>2</sub>	10	1
	none	10	1
	TBP–ZnI <sub>2</sub>	10	2

on differently infiltrated films. Without performed infiltration, the maximum luminance in Mn:ZnS of 0.1 cd/m<sup>2</sup> and the quantum efficiency of 10<sup>-6</sup> photons per electron are very low. The electronic stability of such devices is weak, too. By infiltrating the nanoporous films with zinc oxide clusters or TBP-complexed zinc chloride (see Experimental Section), the luminance increased by 1 order of magnitude. The most

Ex. 1096 (Leeb) at 7843

## Benefits of using MCCs to seed growth of nanoparticles were well known and support obviousness

- Prior art taught benefits of MCCs
  - greater synthetic control
  - lower reaction temperatures
  - improved nanoparticle properties
  - better reaction scalability

### Khitrov

methodology is the attainment of greater synthetic control. The use of a cluster based single source precursor allows nanomaterial growth to be initiated at low temperature without a requisite pyrolytic step for nucleus formation traditionally required for lyothermal growth processes. The elimination of the pyrolytic step <sup>1</sup> allows greater synthetic control, <sup>2</sup> slow thermodynamic growth at lower temperatures, <sup>3</sup> high crystallinity, and <sup>4</sup> reaction scalability.

Ex. 1069 (Khitrov) at 44;  
see also Ex. 1045 (Cumberland) at 1584; Ex. 1010 (Yu) at 9198



Dr. Cossairt  
PO's Expert

- PO's expert admits benefits of using MCCs were known

Q Why is it important that each molecular cluster compound must be identical?

A That's a very interesting question. It depends -- so it depends on how they are being used and the goal of the synthesis. So if the goal of the synthesis is to make various sized uniform nanoparticles, then you would want your seeds to be identical.

Q And that was known in the 2004 timeframe, right?

A Yes. It was understood that using more size-uniform seeds would be expected to result in more size-uniform products, yes.

\* \* \*

Q Would a person of ordinary skill in the art have known that using molecular cluster compounds could allow you to use a lower reaction temperature?

A A person of ordinary skill in the art would understand that using a seed, in general, would be expected to allow you to use a lower reaction temperature.

Ex. 1099 at 49:20-50:7, 81:17-82:3

Q Why would a person of ordinary skill in the art have wanted to use a molecular cluster compound to make nanoparticles?

MR. NEWMAN: Objection.

THE WITNESS: I think there are many possibilities and it would be hard to, you know, come up with all the -- all of them.

BY MR. WILSON:

Q Can you provide an example?

MR. NEWMAN: Same objection.

THE WITNESS: We talked about this earlier, as well, where -- I will give one example -- that using a molecular cluster compound where every cluster is the same would have benefits in terms of having very uniform seeds that would grow more uniform nanocrystals via, you know, a specific mechanism.

But there's lots of different possible mechanisms for applying these cluster compounds, so there's lots of different answers that you could come up with from this.

Ex. 1099 at 80:10-81:15

## A POSITA would have had a reasonable expectation of success of using a Zn-based MCC to seed growth of Group III-V QD

- **Zaban** (Ex. 1006) - InP QDs using Zn-based precursor
- **Yu** (Ex. 1010) – In nanoparticles using Au seeds
- **Banin** (Ex. 1005) – InAs nanorods using catalyst such as Zn or alloys thereof



Dr. Cossairt  
PO's Expert

Q Well, what is your understanding of heterogenous seeded growth?

A It would be using a seed of a different composition than the material you're growing on it.

Q And using that definition, that was known in the art prior to 2004, right?

A Yes.

Q Now, why would a person of ordinary skill in the art have wanted to use heterogenous rather than homogenous seeded growth?

MR. NEWMAN: Objection.

THE WITNESS: I think there's many possible reasons.

Ex. 1099 at 75:17-76:10

Q So one reason would be to use it to tailor the properties of the nanoparticle. Is that what you are saying?

A Yeah, that's one.

Ex. 1099 at 77:22-78:4

## Contrary to PO's arguments, Zaban does not "require" a specific amount of zinc in the core of the nanoparticle

### PO's Sur-Reply

incorporate low levels of [the transition metal]”). Zaban unequivocally stresses the importance of using a very particular amount of zinc. Ex. 1006, 3154; Ex. 2030, ¶

IPR2021-00186, Paper 39 at 22; see also IPR2021-00183, Paper 40 at 22;  
IPR2021-00184, Paper 39 at 20; IPR2021-00185, Paper 40 at 17

- **Zaban does not say:**
  - One zinc atom is required
  - One zinc atom is optimal
  - More zinc would not work
  - One zinc atom was used for any particular reason
- **Zaban only says, in its reaction, each resulting QD happened to have “on average one Zn<sup>2+</sup> ion”**

### Zaban

**Synthesis of Colloidal InP QDs.** Colloidal InP QDs were synthesized by colloidal chemistry methods using indium oxalate and tris(trimethylsilyl)phosphine (P(SiMe<sub>3</sub>)<sub>3</sub>) as starting reactants; the reactants are heated for 3 days at 260–280 °C in the presence of trioctylphosphine oxide (TOPO) and trioctylphosphine (TOP). Details of the preparation are given in ref 14. During the synthesis, the QDs are capped with TOPO/TOP, which produce a compact hydrophobic shell on the QD surface.<sup>15</sup> p-Type (InP:Zn), n-type (InP:S), and undoped QDs of InP were synthesized as well-crystallized zinc blende nanocrystals. For synthesis of p-type InP QDs, indium oxalate was mixed with zinc acetate in a ratio such that the resulting QDs contain on average one Zn<sup>2+</sup> ion per particle. For example, for 40-A QDs, the ratio In:Zn is 10<sup>3</sup>:1. For n-type InP QDs, P(SiMe<sub>3</sub>)<sub>3</sub> was mixed with (bis(trimethylsilyl) sulfide) and then the indium salt was added. The TOPO/TOP caps on the InP surface are replaced with 4-*tert*-butylpyridine (TBP) ligands by dispersing QDs in toluene solution containing an excess of TBP, followed by precipitation and washing with methanol; this ligand exchange process was repeated several times to ensure complete capping with TBP.

Ex. 1006 (Zaban) at 3154

## PO's argument that using Ptatschek's or Farneth's MCCs will have 10x the amount of zinc "required by Zaban" is without merit

- Zaban does not require a specific amount of zinc and itself provides encouragement to try adding more zinc

sized as well-crystallized zinc blende nanocrystals. For synthesis of p-type InP QDs, indium oxalate was mixed with zinc acetate in a ratio such that the resulting QDs contain on average one  $Zn^{2+}$  ion per particle. For example, for 40-Å QDs, the ratio In:Zn is  $10^3:1$ . For n-type InP QDs,  $P(SiMe_3)_3$  was mixed with (bis-

Ex. 1006 (Zaban) at 3154

recombination of injected electrons with  $I_3^-$ . We found that p-type InP/TiO<sub>2</sub> electrodes are stable during illumination while n-type InP/TiO<sub>2</sub> electrodes photocorrode in the electrochemical cell. The reason for this behavior is not understood. Perhaps the p-type InP produces

Ex. 1006 (Zaban) at 3156



Dr. Cossairt  
PO's Expert

- PO's expert admits adjusting concentrations was within a POSITA's ordinary skill

Q Okay.

So if you had -- if you had a solution of salt water, would a person of ordinary skill in the art have known how to decrease the concentration of salt in the salt water?

A Sure.

Q And how would they do that?

A Add more water.

Q Similarly, would a person of ordinary skill in the art had known how to increase the concentration of the salt in salt water?

A Sure. Add more salt.

Ex. 1099 at 134:18-135:9

## PO's 10x argument as it pertains to size is also without merit

- PO's argument about decreased QD size is unsupported



**Dr. Green**  
Pet'r's Expert

45. PO also argues that adding more zinc to Zaban's QDs would reduce the size of those QDs. POR 50 (citing Ex. 2025, 3). I disagree. PO relies on the Mordvinova article, which involves zinc concentrations at least 500 and 2000 times higher than the zinc concentrations disclosed in Zaban. Ex. 2025, 3; Ex. 1006, 3154. There is nothing to suggest (either at the time of the alleged invention or now) that increasing the zinc concentration in Zaban's process by a mere factor of 10 would decrease the size of the QDs. Additionally, even if Mordvinova had been known

IPR2021-00185, Ex. 1093 ¶ 45

- PO's expert admits none of the claims require nanoparticles to be a specific size



**Dr. Cossairt**  
PO's Expert

**Q** None of the claims of the '828 patent require the nanoparticles to be a specific size, correct?

**A** Correct.

Ex. 1099 at 98:3-6; see also *id.* at 86:9-11, 93:21-94:16, 101:14-15

- Summary of IPRs and Disputed Issues
- **Banin Grounds**
  - Anticipation
  - Obviousness
    - Alone
    - + Herron/Farneth, + Bawendi, + Treadway, + Braun
- **Zaban Grounds**
  - Obviousness
    - + Ptatschek/Farneth
    - + Yu, + Braun, + Bawendi

## Contrary to PO's argument, a POSITA would have been motivated to add Yu to the combination of Zaban and either Ptatschek or Farneth

- Yu supports heterogeneous seeded growth using lower reaction temperatures



Dr. Green  
Pet'r's Expert

nanoparticles). Ex. 1010, 9198. Moreover, Zaban—which PO does not dispute incorporates the synthesis reaction details disclosed in Mičić's—itself teaches the temperature limitations recited in claims 4-6 and 25, with Yu merely providing a POSITA with further confirmation that the QD synthesis method disclosed in Zaban would succeed in making nanoparticles at the lower temperatures of 140-150°C using the zinc-based MCC disclosed in Ptatschek as a seed. Ex. 1002 ¶¶186-98.

IPR2021-00184, Ex. 1093 ¶ 54; IPR2021-00185, Ex. 1093 ¶ 51; see also IPR2021-00183, Ex. 1093 ¶ 63; IPR2021-00186, Ex. 1093 ¶ 62



Dr. Cossairt  
PO's Expert

Yu teaches using Hutchison's gold clusters to make metal nanoparticles at low temperatures. See Ex. 1002 (Green Decl.) at ¶ 160 (Yu teaches “sufficiently low temperatures” ... “ranging from room temperature to 150 °C.”). Such temperatures are so low that the gold particles remain solid in solution and can act as seeds. See generally, Ex. 1010.

IPR2021-00186, Ex. 2030 ¶ 141

- PO's expert admits MCCs were known to allow use of lower reaction temperatures



Dr. Cossairt  
PO's Expert

**Q** Would a person of ordinary skill in the art have known that using molecular cluster compounds could allow you to use a lower reaction temperature?

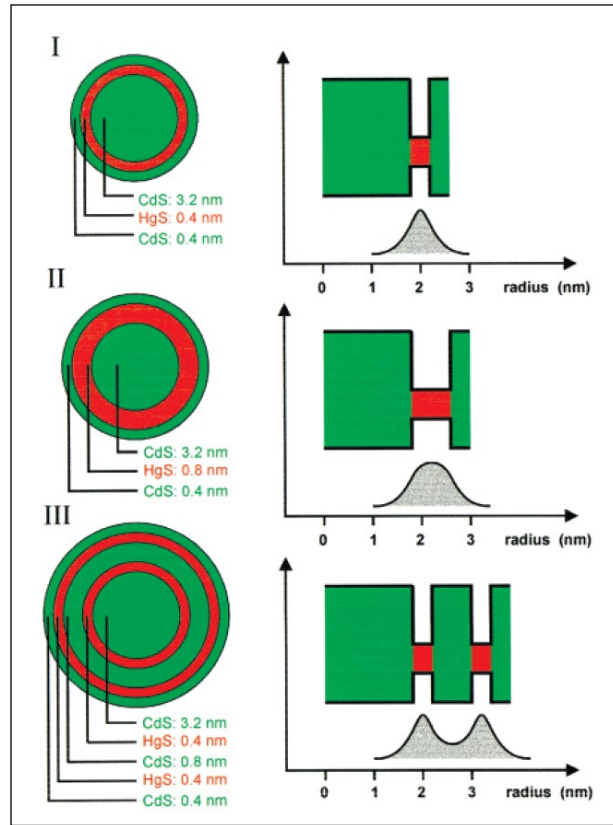
**A** A person of ordinary skill in the art would understand that using a seed, in general, would be expected to allow you to use a lower reaction temperature.

Ex. 1099 at 81:17-82:3

# Zaban Grounds: + Ptatschek/Farneth + Yu + Braun

## A POSITA would have been motivated to add Braun to the combination of Zaban, Ptatschek or Farneth, and Yu

### Braun



Ex. 1013 (Braun) at 5549, Fig. 1



Dr. Cossairt  
PO's Expert

Q And in 2004 -- or by 2004, it was known that you could add more than one shell layer to a nanoparticle, correct?

A That's correct.

Q These were known as core multi-shell nanoparticles; is that right?

A Yeah, or sometimes core-shell shell.

Ex. 1099 at 51:7-15



Dr. Green  
Pet'r's Expert

characteristics. Ex. 1013, 5549. As discussed in §IV.C, it is my option that to take advantage of the improved optical properties of a nanoparticle with enhanced quantum confinement structures, a POSITA would have been motivated use the method for synthesizing nanoparticles of Zaban in view of Ptatschek to create multi-shell nanoparticles as taught by Braun.

IPR2021-00185, Ex. 1002 ¶ 131

### Banin

Rod/shell nanocrystals based on InAs nanorods, e.g. InAs/ZnSe or InAs/CdSe, may be prepared to improve the photoluminescence quantum yield and to provide further control of the optical and electronic properties of the nanorods [19, 20].

Ex. 1005 (Banin) at 25:12-15