



# Novel Plasmonic Materials for Energy-Related Devices

César Clavero, Ph.D. Research Scientist Lawrence Berkeley National Laboratory



André Anders, Senior Scientist and Plasma Applications Group Leader, LBNL Jonathan Slack, Senior Scientific Engineering Associate, LBNL César Clavero, Research Scientist, LBNL

Visit this Poster!! : "Filtered Cathodic Arc: High Quality Aluminum-doped Zinc Oxide on Plastic and Glass" **Jonathan Kolbeck**, Technical University of Berlin, LBNL











### Outline

- •What are PLASMONIC materials?
- Opportunities in PLASMONIC materials
  - Smart Windows
  - •Solar Cells
- •Our approach: Terminated Cluster Growth
- Future directions
- •Summary



### What are PLASMONIC materials?

#### Localized Surface Plasmon Resonance (LSPR)





#### **Plasmonic Materials**



### Opportunities in Plasmonic materials: **Smart Windows**









<u>Ultimate Goal:</u> independent switching in the visible and infrared ranges



### Opportunities in Plasmonic materials: **Smart Windows**

### Solution based fabrication of nanocrystals, Molecular Foundry, LBNL



G. Garcia, R. Buonsanti, E. L. Runnerstrom, R. J. Mendelsberg, A. Llordes, A. Anders, T. J. Richardson and D. J. Milliron, Nano Letters **11** (10), 4415-4420 (2011).

•Some materials and phases cannot be produced using solution based methods

•Technology for large scale deposition not developed yet



### Opportunities in Plasmonic materials: Plasmonic Solar Cells

### Plasmonic solar cells



H. A. Atwater and A. Polman, Nat Mater **9** (3), 205-213 (2010).

#### All-plasmonic solar cells











Source: Mantis Deposition LTD





Mantis Deposition LTD

The nanocrystals size and production rate can be varied by controlling a number of parameters including

Sputtering gas flow rate
Aggregation zone pressure
Position of the target in the aggregation zone
Sputtering power











Oxide nanocrystals can be created by inserting oxygen in the aggregation zone



Mantis Deposition LTD









#### **Optical characterization**





#### Electromagnetic fields modeling : FDTD



•Ellipsometry

•Fourier transform infrared spectroscopy (FTIR)

•Reflectance and transmittance spectroscopy



#### Optical modeling







### Structure and morphology characterization

Rutherford Backscattering Spectroscopy (RBS)



•An energetic alpha beam up to 5 MeV can be generated by the pelletron accelerator

with terminal voltage of 1.7MV
 PIXE and NRA analysis
 Accurate composition analysis



C. Clavero, NCCAVS Joint User Group Topical Conference, February 21, 2013

Channel

### Future directions: conducting oxide plasmonic structures



Conducting oxides allow tuning the optical absorption over most of the visible and near-infrared ranges



## Summary

•Plasmonic materials have interesting applications in energy related devices such as smart windows and solar cells.

•Terminated Cluster Growth is a novel technique for the fabrication of Plasmonic materials. Allows high control on nanocrystal composition and size.





# Thank you!

### **Questions?**

