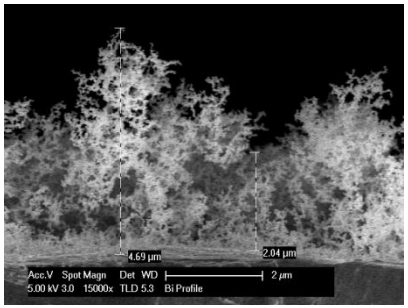
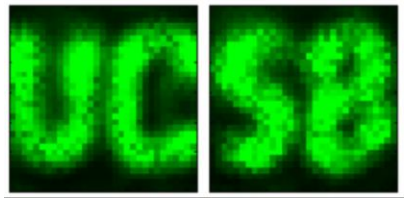
Photoacoustic Ultrasound from Nanostructured Materials



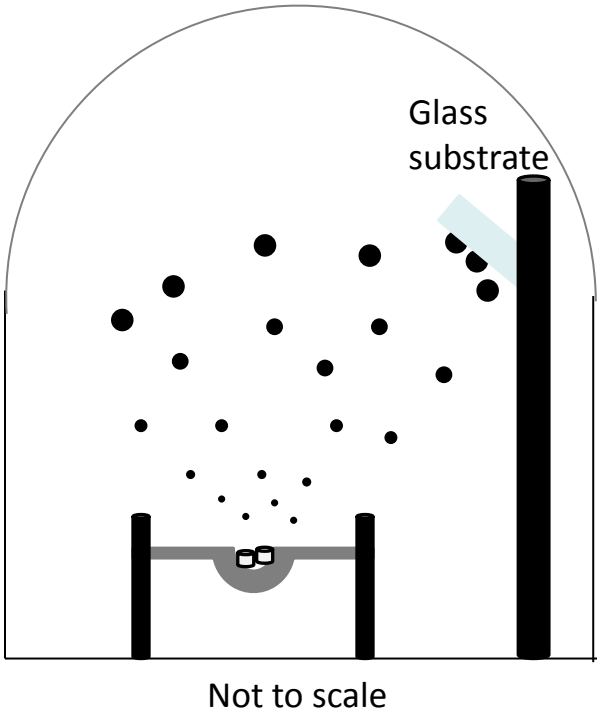


Morgan Brubaker

Weld Group

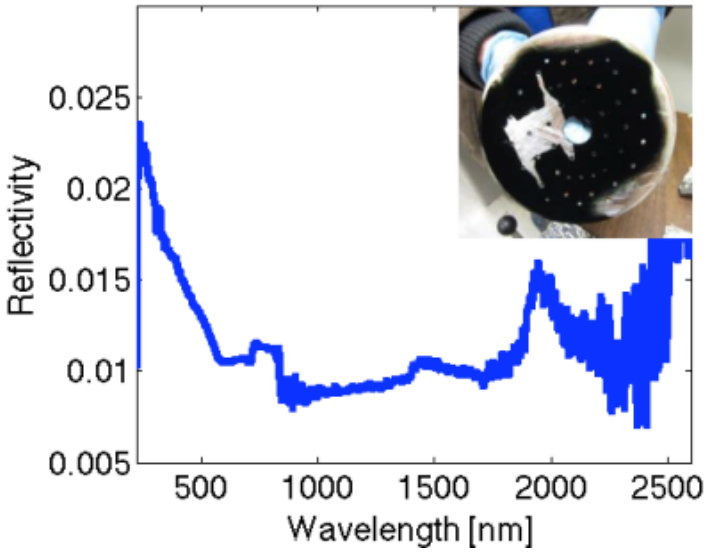
Nanostructured Film Production

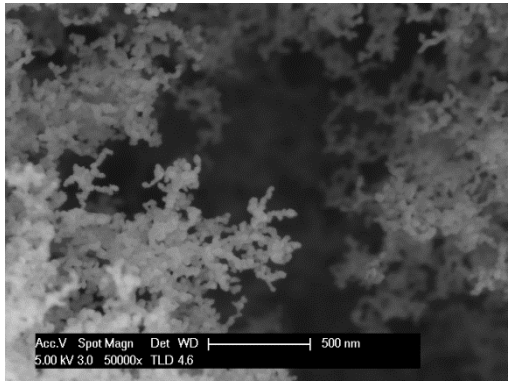
- Materials evaporated in 2 torr noble gas background
- Particles aggregate in gas phase
- Aggregates deposit on surface
- Method works with many materials, including bismuth, copper, iron, nickel, and silicon monoxide



Structure

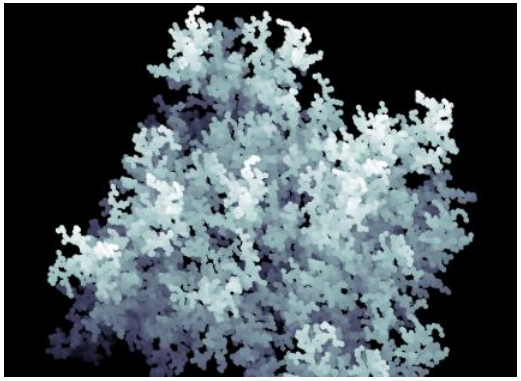
- Fractal nanostructure
- Typically resembles diffusion-limited aggregates
- Poorly connected structure. Very black.
- Length scale on order of 10s of nm
- Not strongly affected by material or evaporation parameters





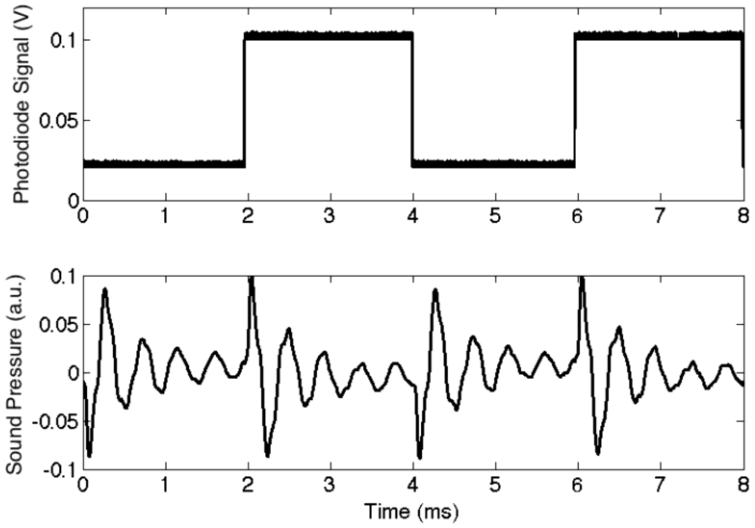
Left: Electron Micrograph of Nanostructured Copper

Right: Simulated model of a diffusion-limited aggregate



Photoacoustic Effect

- Amplitude-modulated light hits sample
- Sample absorbs light and undergoes temperature oscillation
- Causes pressure oscillation in air
- Films can change temperature quickly
- Nanostructure allows for high frequencies
- → Special properties of nanomaterials allow for creation of novel ultrasound sources



$$\frac{1}{\tau} = \frac{\alpha k \gamma}{C}$$

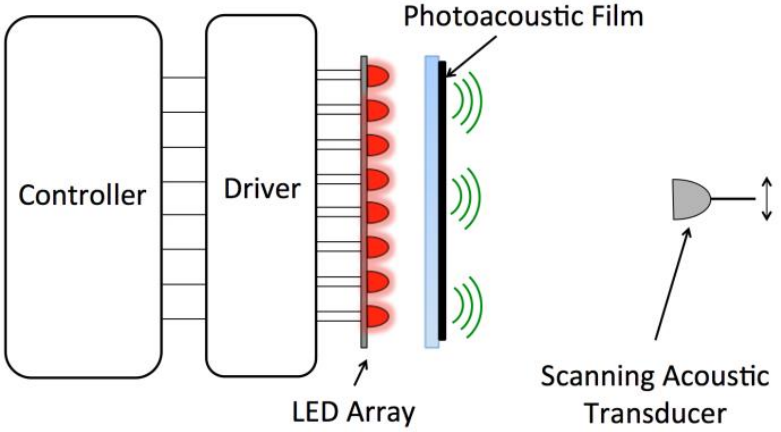
τ =characteristic cooling time in air
C =heat capacity of a granule
α =thermalization constant
k =Boltzmann constant
γ =collision rate between particles and granule

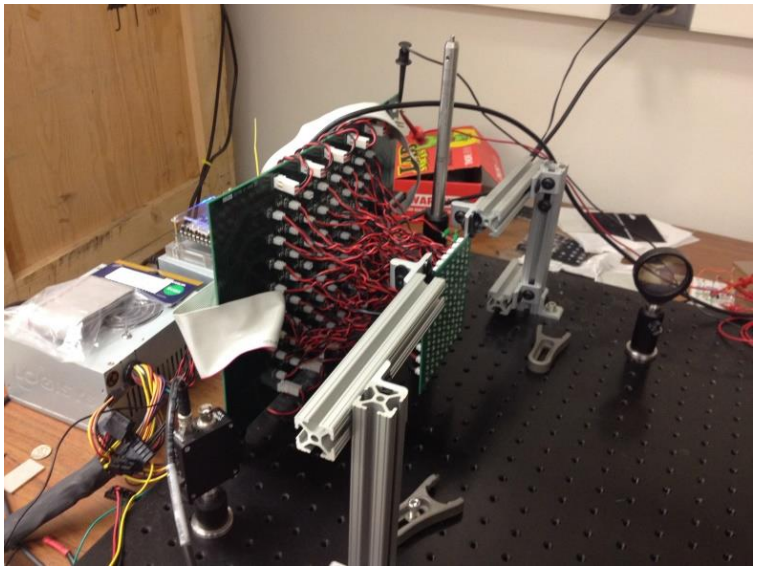
For bismuth, $\frac{1}{\tau} \sim 1$ MHz.

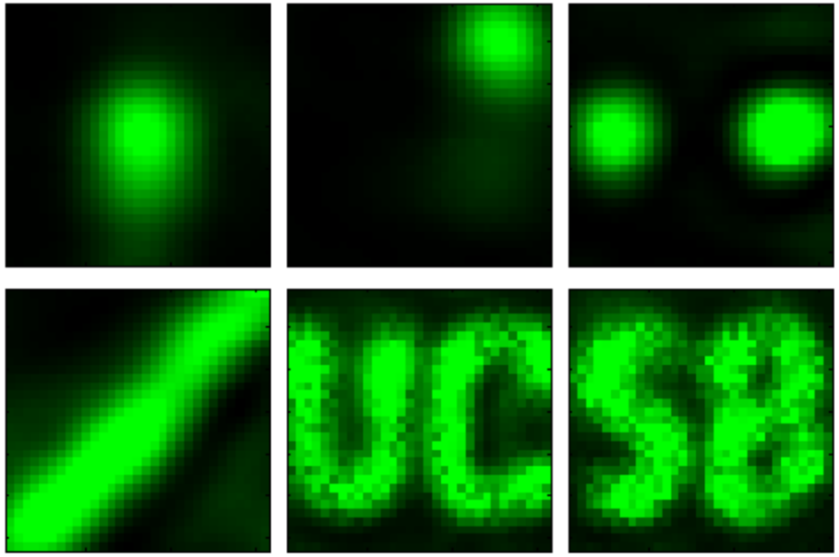
Novel Acoustic Source

Optically Addressed Acoustic Phased Array

- Film transduces light to sound
- Arbitrary phase patterns of sound
- Stationary or Dynamic Foci





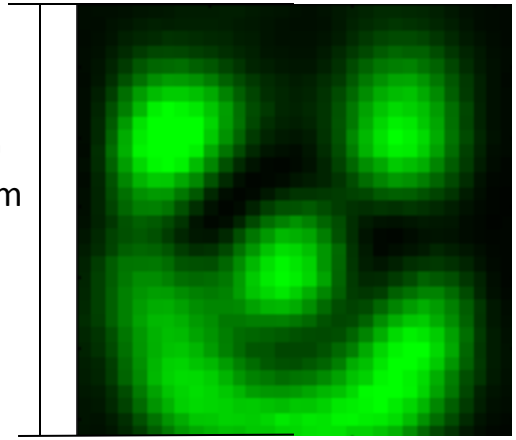


"UC" and "SB": 45mm x 45mm.
All others: 30mm x 30mm

Future Work

Sub-Diffraction-Limited Acoustic Generation

- Ultrasonic tones mix in nonlinear medium
- Generates tightly-focused acoustic tones



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