

Decreasing the Defects in Free-Standing Nickel Inverse Opal Cellular Solid



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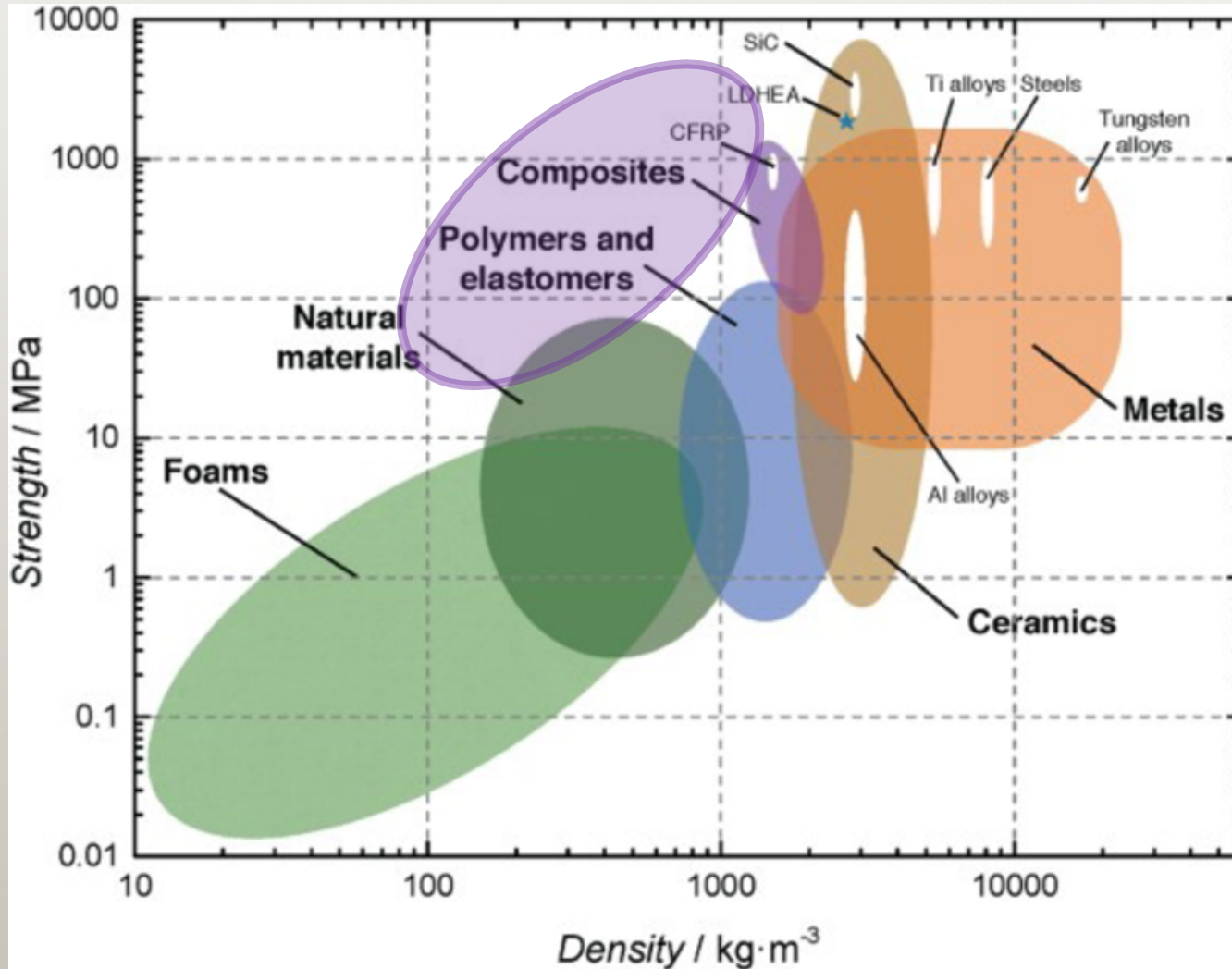
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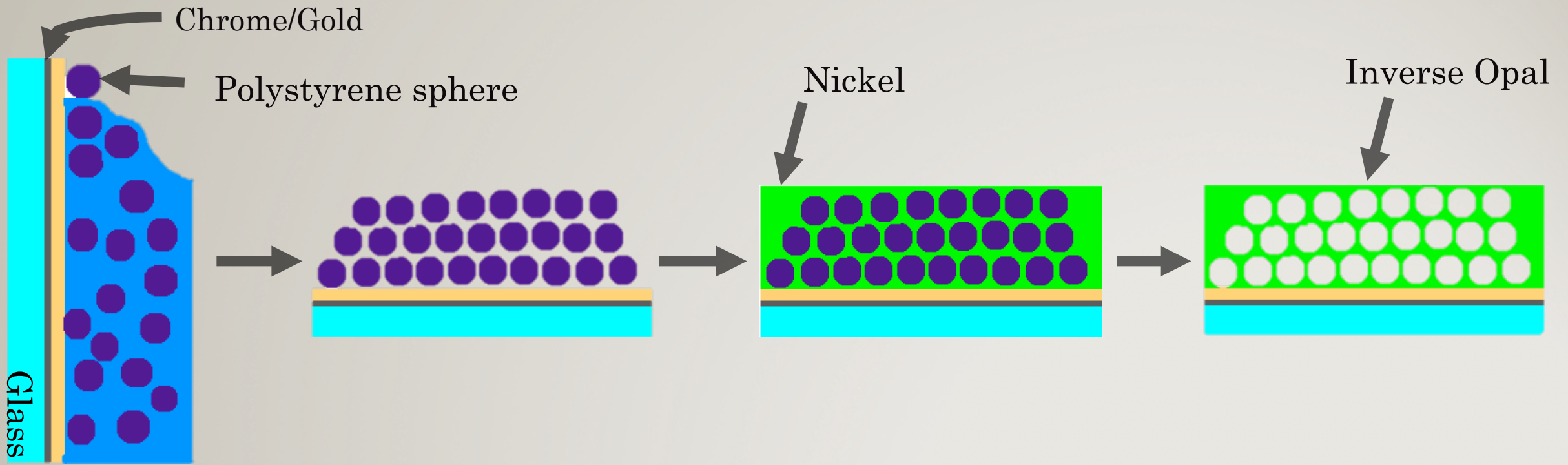


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Focus

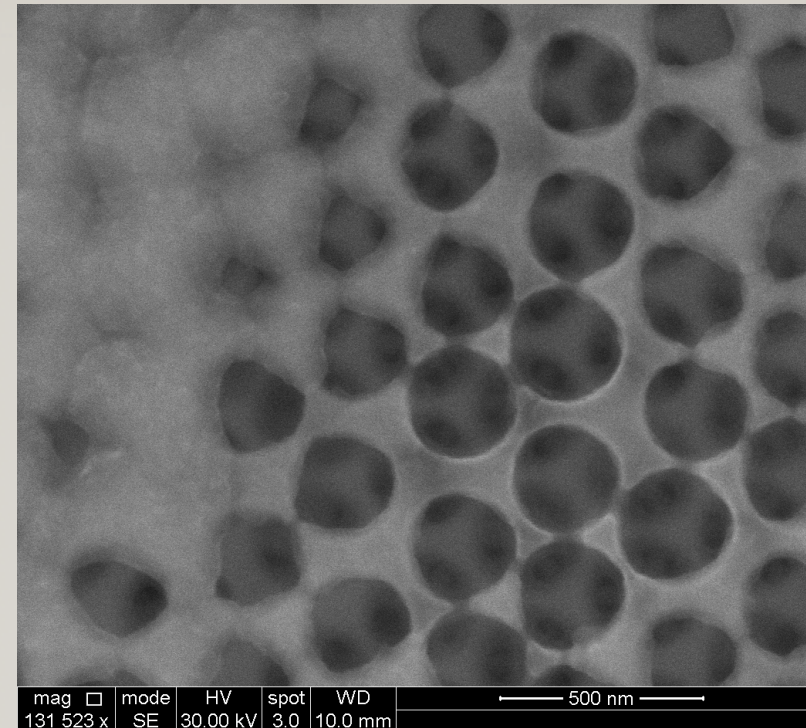
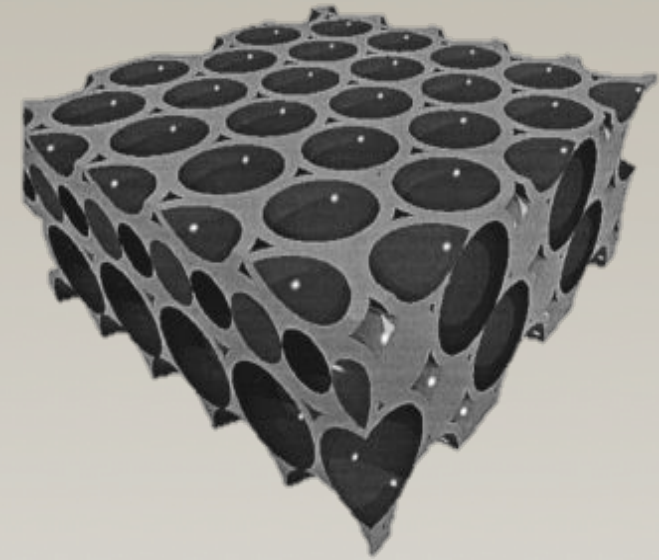
- **Goal: Fabricate a high strength material at a relatively low density.**
 - Strength of metals
 - Density of water
- **Potential uses:**
 - Planes and cars
 - bone replacement



Current method

Background

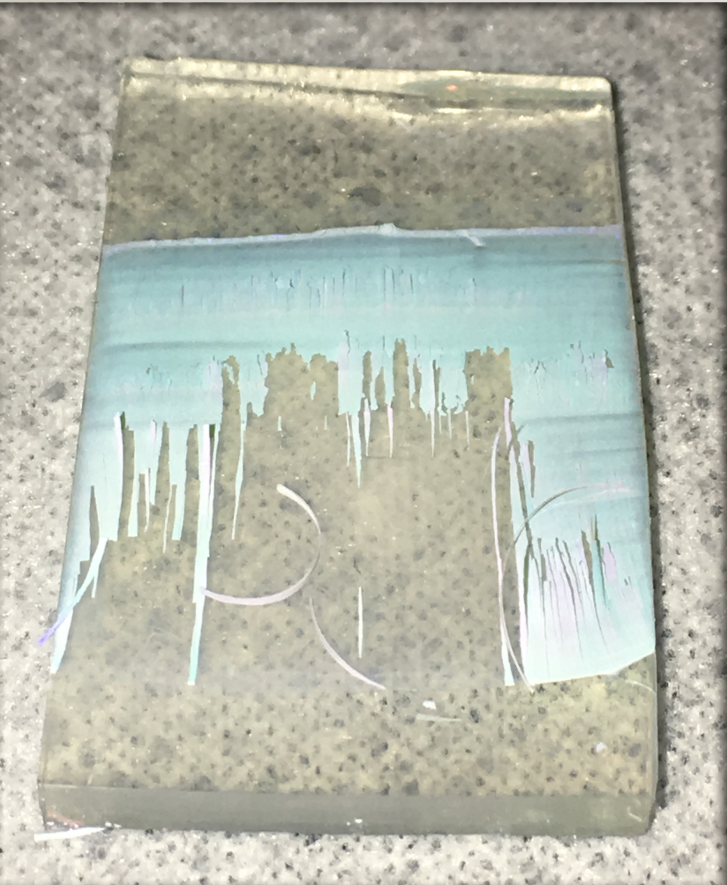
- Material is formed as a nickel inverse opal cellular solid
- Decrease in the pore size leads to an increase in strength¹
 - Previous research has used diameters ranging from 260 to 930 nm²
 - Current diameters range from 200-300 nm.



1. Z. Li *et al.*, *Materials & Design* **45**, 52 (2013)

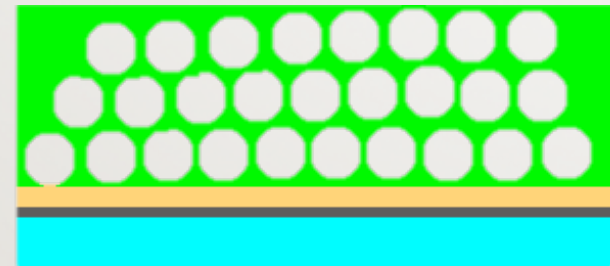
2. Pikul *et al.* Submitted

3."Colloidal Photonic Crystals." Colloidal Photonic Crystals - Soft-Matter. N.p., n.d.

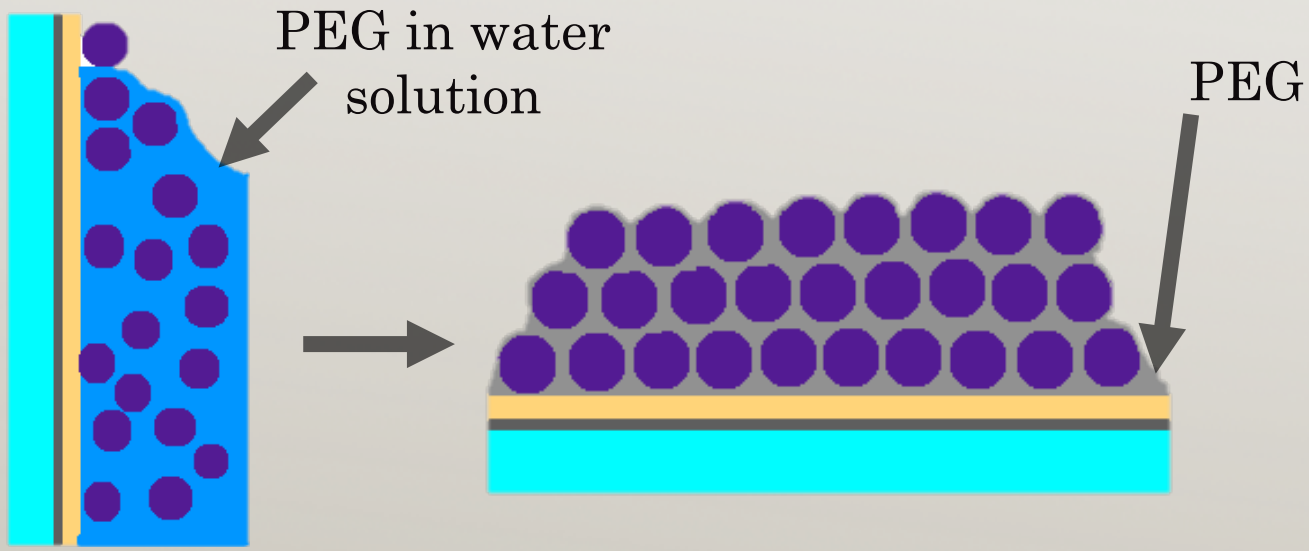


Challenges

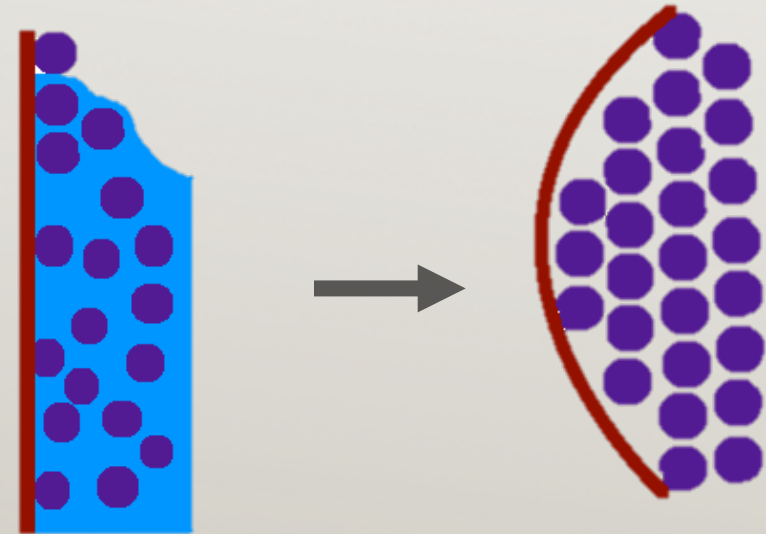
- Problem #1: Opal structures have vertical cracking, which cause polystyrene to remove from the slide.
- Problem #2: To do mechanical testing we need to remove this nickel foam from the glass substrate.



Methods for reducing defects



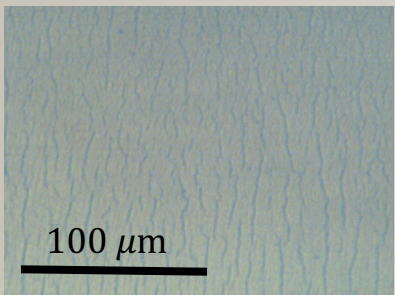
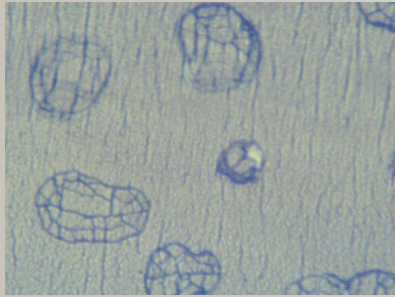
- Introduce polyethylene glycol (PEG) into the starting solution.
 - PEG replaces the space between PS sphere



- Thin copper foil to allow for the substrate to give and bend with the drying process.

PEG Results

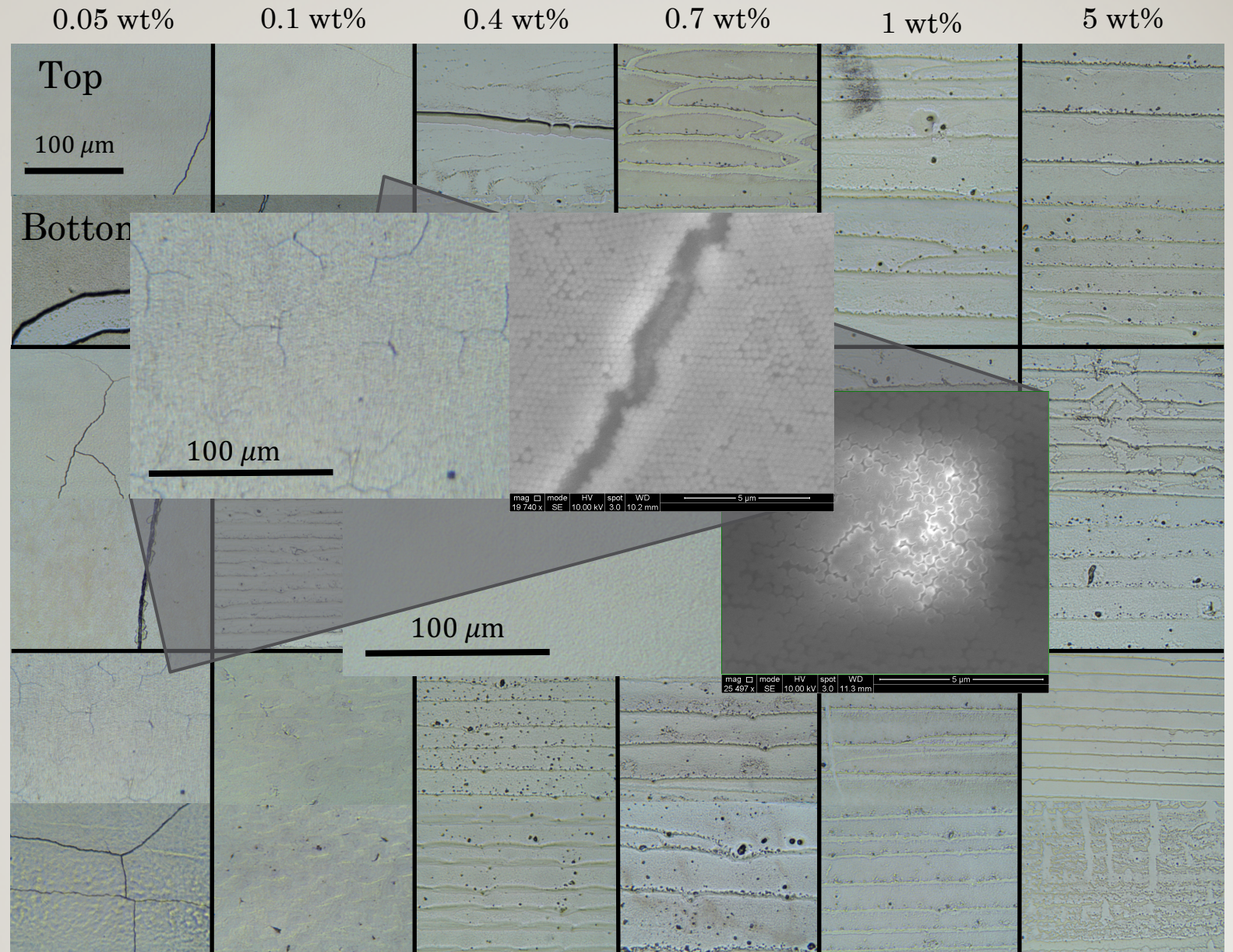
Polystyrene control



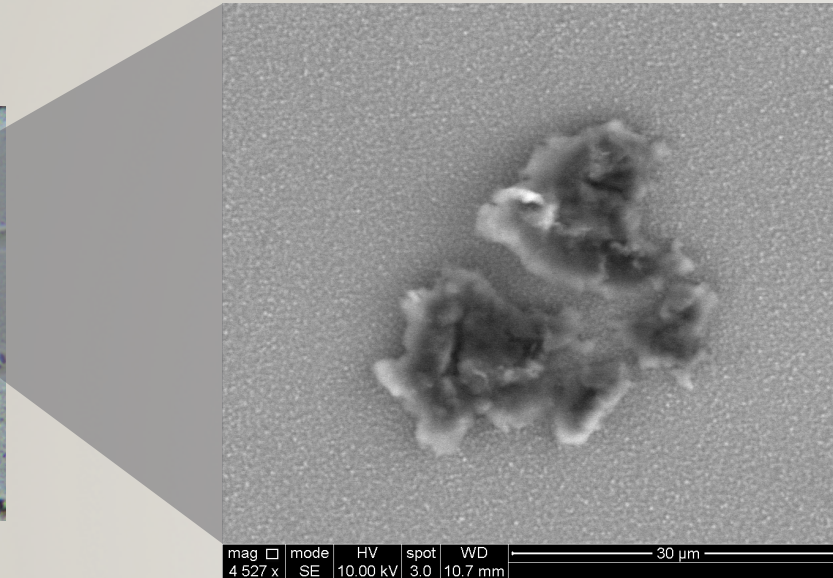
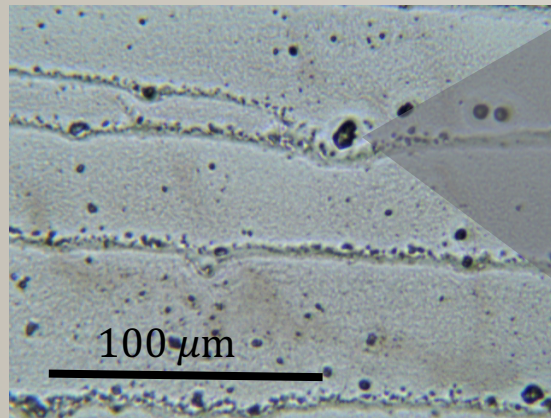
200 g/mol
PEG

1,000 g/mol
PEG

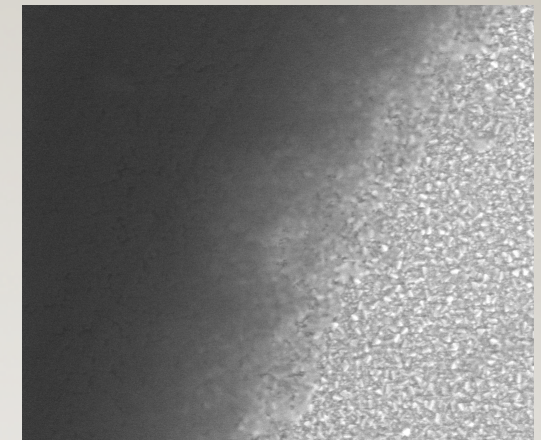
6,000 g/mol
PEG



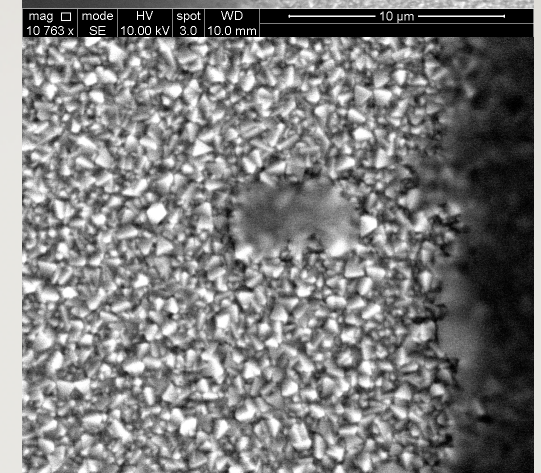
High PEG concentrations



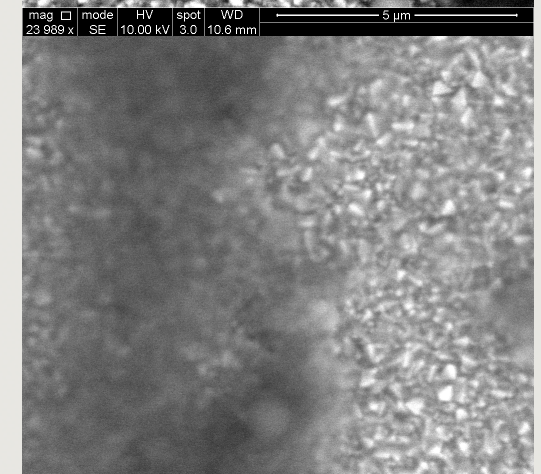
0.4 wt%
200 g/mol



0.7 wt%
200g/mol

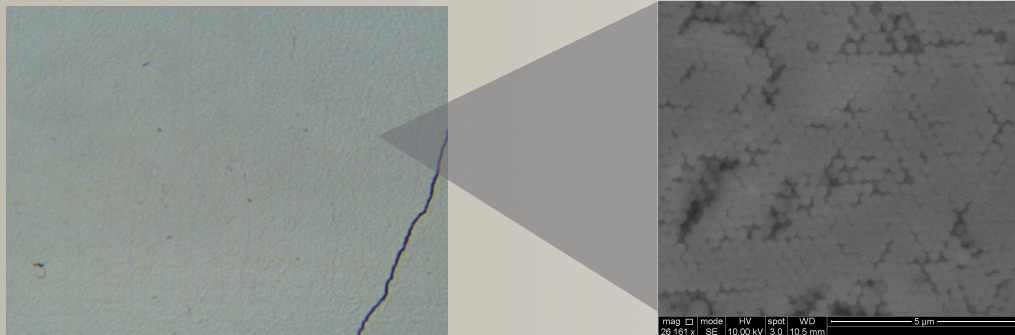


0.7 wt%
6,000 g/mol



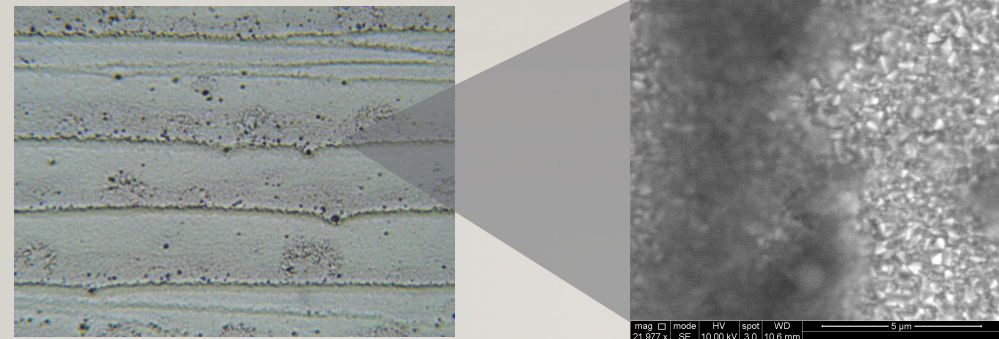
PEG conclusions

- Low PEG weight percent decreases cracking
 - ≤ 0.1 wt%



0.05 wt%
200 mol/g PEG

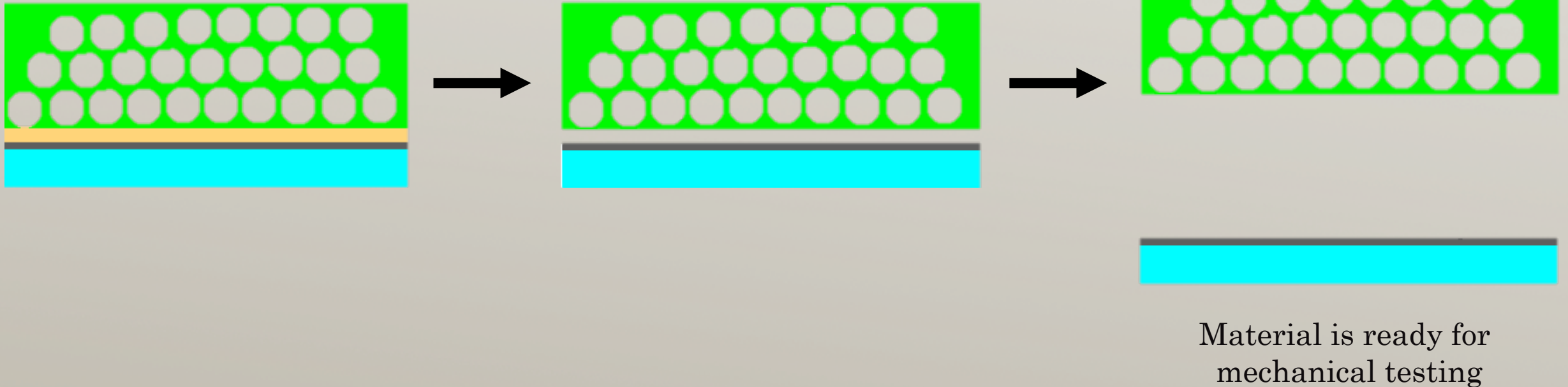
- High PEG weight percent brings striations
 - ≥ 0.4 wt%
 - Alternating areas with and without polystyrene assembly



0.7 wt%
6,000 mol/g PEG

Etchant Removal

- On the gold-chromium slides:
 - Etching the gold layer away to reveal a free standing nickel inverse opal

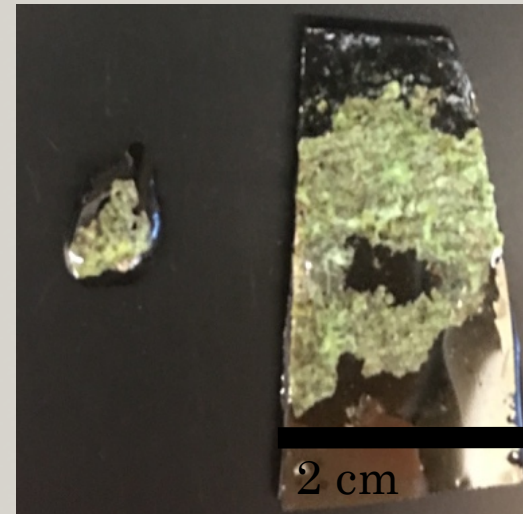
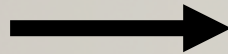


Etchant Removal Results

- GE-8148: successful in removing from slide
- Came in pieces, not one smooth singular sheet like material
- Discoloration of nickel occurred
 - Not supposed to etch nickel, but reaction occurring



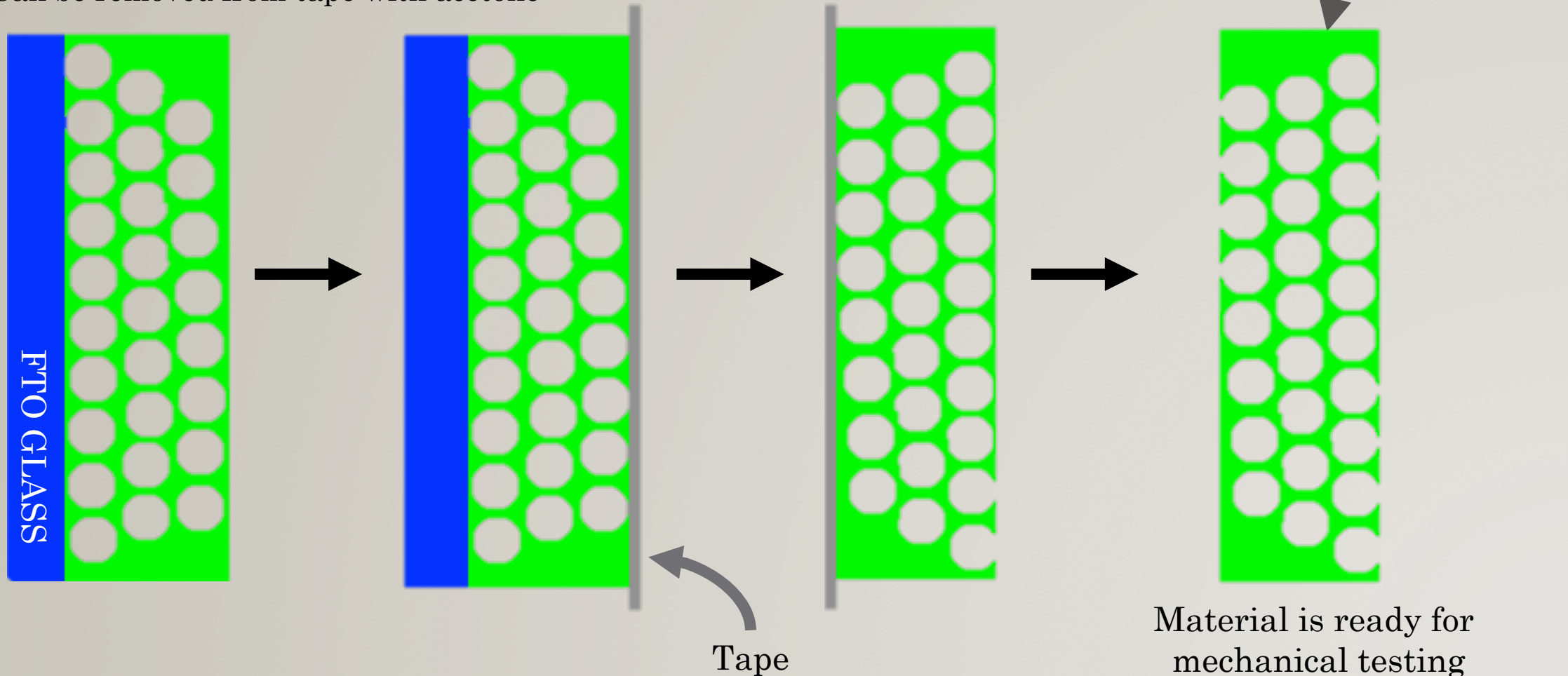
Nickel on gold/chrome slide



Nickel after soaking in GE-1848

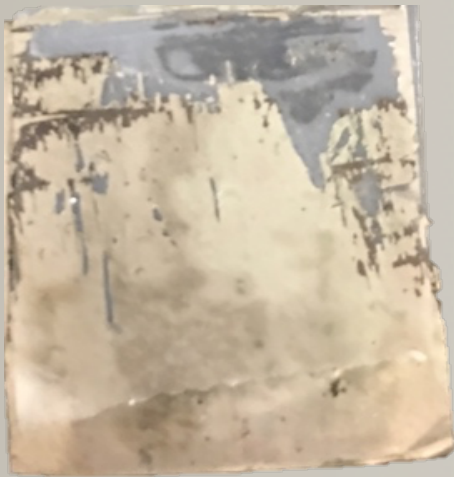
Adhesive removal

- On the FTO slides:
 - Removal through adhesive forces with scotch packing tape
 - Can be removed from tape with acetone

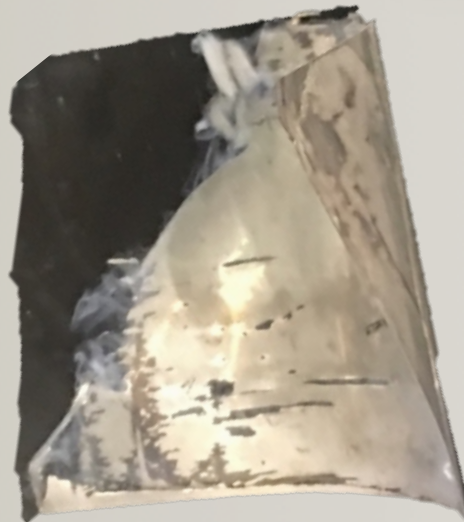


Adhesive Removal Results

- Allowed for a single sheet of nickel
- Tape could be dissolved or removed through acetone
- Mechanical testing could be done with nickel still attached to the tape



Tape on top of nickel on substrate



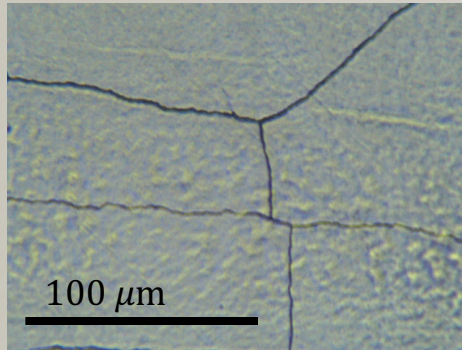
Nickel on tape dissolving in acetone



Free-standing nickel

Conclusions

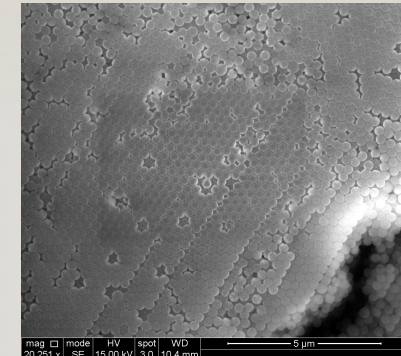
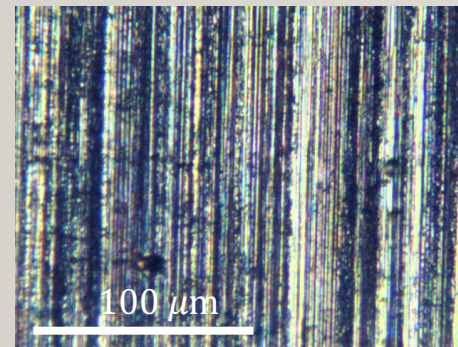
- Decreased the vertical cracking with the use of PEG
 - Discovered spider like cracking and striations



0.05 wt% 6,000 g/mol PEG

- Successfully removed the nickel foam from the substrate

- Next steps:
 - Perform mechanical testing
 - Explore discoloration of nickel with gold etchant
 - Grow on thin, flexible substrate
 - Copper



0.05 wt% 6,000 g/mol
PEG on copper

Acknowledgments

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QUESTIONS?