Novel Material and Manufacturing Technology Development for a High Sensitivity, target-Specific Planar Optical-microsensor-array for Remote sensing of Chemical Species

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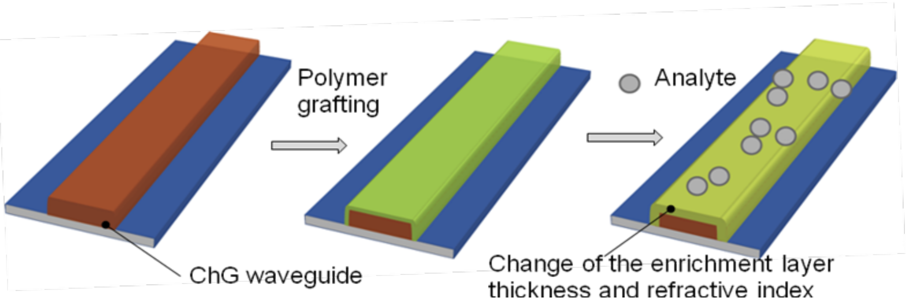
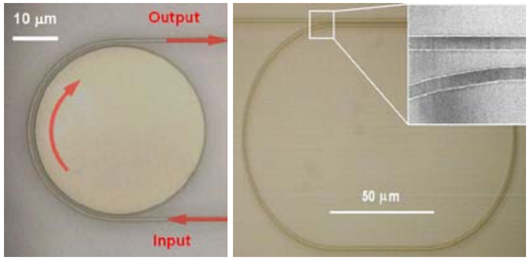
***Program Description*: Development of a novel, highly sensitive and specific, integrated sensor system used for advanced chemical detection and intelligent sensing applications, using chalcogenide materials**



Schematics of enrichment layer for evanescence sensor

Technical issues program will address:

- **Fabrication of new photosensitive Chalcogenide glass families for an operating wavelength range from UV to Visible to Far IR**
- **Deposition of chalcogenide film for planar waveguides using thermal evaporation or sputtering processes**
- **Deposition of a Polymer coatings functionalized with "getters" to selectively bind/de-bind target molecules.**
- **Femtosecond laser irradiation to write buried waveguides or trenches (ablated) in 3D in the films in a single step**
- **Pattern of the film by photolithography and etching**
- **Investigation of the structural modification after laser irradiation using Micro-Raman spectroscopy**
- **Fabrication of an integrate source and detector onto the chip**



Top view optical micro-graph of a racetrack As_2S_3 resonator (a) and an As_2S_3 micro-disk resonator with a pulley coupler configuration (b).

Capabilities relevant to the program

- **Chalcogenide glass-based evanscent field waveguide sensor**
- **CMOS compatible on-chip fabrication**
- **UCF/Clemson/MIT team uniquely combines fs laser processing, detector characterization and materials.**

Sponsors and selected recent related publications

- **DOE- PNNL NA-22 program**
- ***Invited* "Development of novel integrated bio/chemical sensor systems using chalcogenide glass materials," L. Petit, N. Carlie, B. Zdyrko, I. Luzinov, K. Richardson, J. Hu, A. Agarwal, L. Kimerling, T. Anderson, and M. Richardson, Int. J. of Nanotechnology, 6 (2008) 799-814**
- **"Planar waveguide-coupled, high-index-contrast, high-Q resonators in chalcogenide glass for sensing", J. Hu, N. Feng, N. Carlie, L. Petit, A. Agarwal, K. Richardson, and L. Kimerling, Optics Letters 33, 2500 (2008).**

Manufacturing Science of Improved Precision Molded Optics

K. Richardson
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I. Luzinov
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***Program Description*: Examination of workpiece (glass) behavior, simulation and corresponding experimental verification of molding process dynamics, and specialized coatings to extend mold life.**

Capabilities relevant to the program

- **Advanced understanding of workpiece/mold material interaction,**
- **Fundamental knowledge of how glass type dictates mold selection material to reduce chemo/thermal/mechanical degradation, shortening tool lifecycle**
- **Establishment of a model which will provide a predictive tool whereby a variety of glass types (chemistry) and mold material types,**

Sponsors

Edmund Optics, ARO, DEPSCoR

Technical issues program will address

- **Evaluating surface quality of pre- and post- molded optical components as well as the molds themselves**
- **Analyze material interaction as it pertains to varying glass type and mold materials**
- **Establish a knowledge of the glass property behavior as a result of being exposed to the molding process**

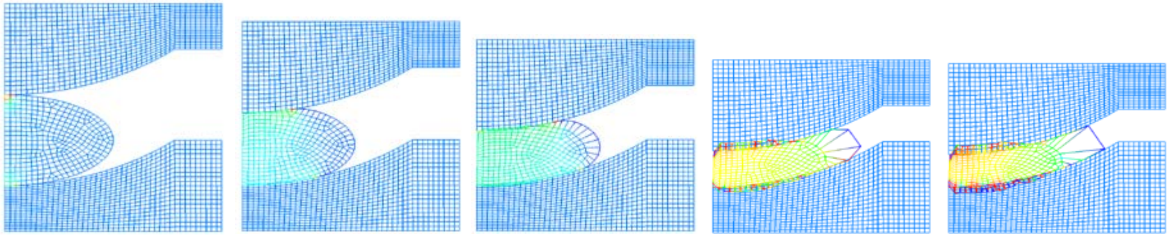
Publications

"Thermal and Structural Property Characterization of Commercially Moldable Glasses", S. Gaylord, B. Ananthasayanam, L. Petit, C. Cox, U. Fotheringham, P. Joseph, K. Richardson, accepted for publication in Journal of the American Ceramic Society

"Viscosity Properties of Sodium Borophosphate Glasses", S. Gaylord, B. Tincher, L. Petit, K. Richardson, Materials Research Bulletin 44 (2009) 1031–1035

Conference Presentations

- ***SPIE OPTIFAB, Rochester NY, (2009)***



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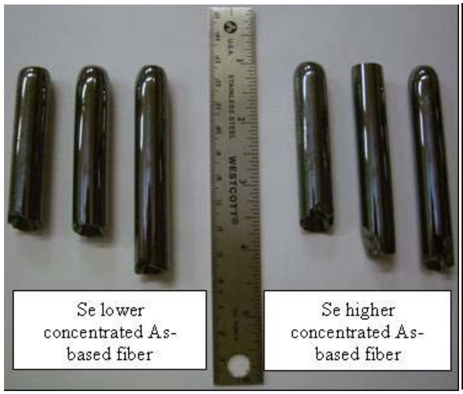
Novel Oxide and non-oxide fibers for IR applications

K. Richardson Clemson University

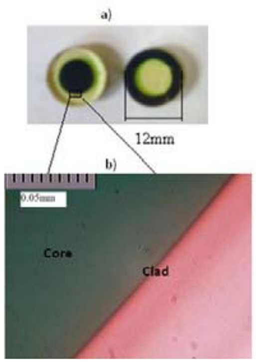
Program Description: **Glass development processes which will yield high optical quality, bulk glasses in preform format, which will be drawn into fiber form and assessed for their optical and physical performance specifications**

Core preforms

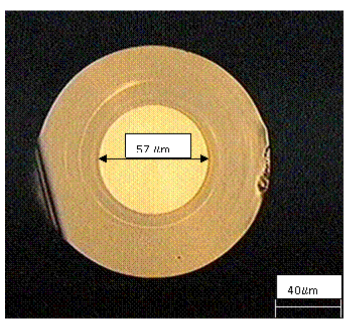


Picture of As-Se preforms

Picture of tellurite and borophosphate preforms.



Photograph (a) and optical image of the Cu-doped core-clad interface (b)



Optical micrograph of the core-clad fiber cross-section using 50X magnification.

Technical issues program will address:

- **Identification of a series of promising glass systems that will produce candidate MIR glass materials suitable for fabrication into low loss (< 0.1dB/m) glass fibers**
- **Development (melting) and characterization of glasses which aim to meet the target attributes: high linear refractive indices, good mid-IR transparency, and the needed thermal-mechanical stability and laser damage resistance**
- **Study of the composition-structure-property variation related to target material attribute goals**
- **Initial fiber formation tests**

Capabilities relevant to the program

- **Material identification, design and fabrication of oxide and chalcogenide fibers**
- **Evaluation of pre- and post- fiberization process-induced surface/structural changes: Micro-structural characterization using micro-Raman spectroscopy**

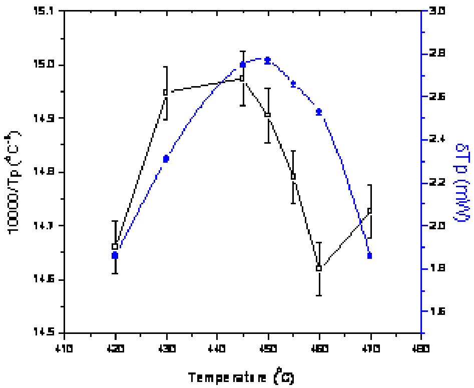
Sponsors and selected recent related publication

- **Air Force Research Laboratory, Raytheon Corporation/Missile Systems Division, NSF**
- **"Thermal and structural characterization of arsenic based rich selenium fibers", L. Petit, N. Carlie, K. Richardson, Materials Science and Engineering B, 156 (2009) 32–35**
- **"Processing and characterization of a new core-clad tellurite glass preforms and fibers using a rotational caster", J. Massera, A. Haldeman, D. Milanese, H. Gebavi, M. Ferraris, P. Foy, J. Ballato, R. Stolen, L. Petit, K. Richardson, submitted to Optical materials**

Nucleation and growth behavior of glasses

K. Richardson Clemson University
M. Davis, SCHOTT North America
S. Misture, Alfred University

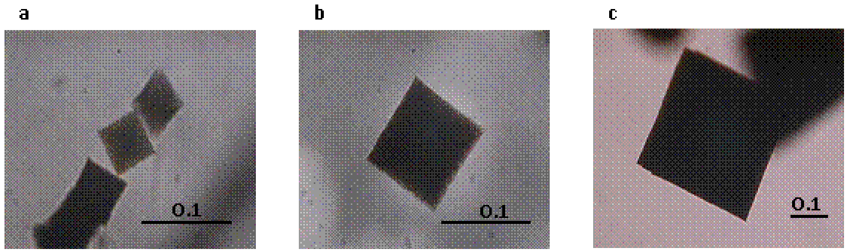
***Program Description*: Effect of glass composition on the nucleation and growth behavior of glasses**



Nucleation-like curve of Lithium Disilicate (LS2)
The maximum of the curve, commonly called the temperature of maximum nucleation, is measured at (445±2)°C. This corresponds to the temperature the glass needs to be heat treated to nucleate a maximum number of nuclei.

Technical issues program will address:

- **Identification of novel glasses suitable for the engineering of novel fibers and thin films for mid-IR applications**
- **Determination of the nucleation- and growth-like curves, the activation energy for crystallization, Johnson-Mehl-Avrami (JMA) exponent, and nucleation and growth rates of glasses**



Optical microscope images of crystal seen in an oxide glass heat treated at 390°C for 4 (a), 8(b) and 39hrs (c). These pictures were taken using a plane polarized light with a x50 (a and b) and a x20 objective (c)

Capabilities relevant to the program

- **Material identification, design and fabrication of oxide and chalcogenide fibers and thin films with controlled nucleation and growth behavior.**

***Recent related publications* and presentations**

- **NSF**
- **"Nucleation and growth behavior of TeO_2-Bi_2O_3-ZnO glasses," J. Massera, I. Moog, J. Remond, L. Petit, and K. Richardson, 8th Pacific Rim Conference on Ceramic and Glass Technology, Symposium on Glasses for Optoelectronic and Optical Applications- Photosensitivity in Glasses, Vancouver BC, Canada (2009)**
- **"Nucleation and Growth Behavior of Tellurite based glasses", J. Massera, J. Remond, M. Davis, L. Petit, K. Richardson, Crystallization 2009, 9th International Symposium on Crystallization in Glasses and Liquids, Foz Do Iguacu, Brazil, September 10th – 13th, 2009.**