Glass: the World's Best Optical Material

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Glass is ubiquitous. Perhaps that's why it is rarely considered a high technology material. It is certainly the best linear optical material in the world. Unlike its crystalline counterparts, glass can have an almost arbitrary range of compositions. It can be pulled into fiber, deposited into films, molded or cold worked by chemo-mechanical grinding and polishing. It can be made as some of the purest solids known, or some of the most contaminated. Vast quantities of it can be made for mass consumption, such as substrates for flat panel displays. It was one of the first and most common laser hosts. Compared to single crystalline materials, glass is extremely inexpensive to make.

Modern applications are pushing glass into new realms. Even simple glasses, such as silica or germania:silica, behave mysteriously in the new regimes. It has been known for over a decade that it is possible to induce second order optical non-linearities in specially prepared silica glasses. Phase gratings can be permanently recorded in germania:silica glasses containing certain optically active defects. Other types of defects in pure silica cause photo-darkening and densification when exposed to ultraviolet light.

Much more complicated, multi-component glasses are being developed for high gain laser hosts. Water-related impurities and associated defects determine to large measure the optical gain in a rare-earth doped laser glass.

The chemical, mechanical and optical properties of a glass can be controlled almost independently by synthesizing a transparent glass ceramic, or TGC. TGCs are typically made by annealing a multi-anion glass, such as an oxyfluoride. The oxide and halide phases segregate and form crystallites. By controlling the anneal schedule and glass composition, the crystallite size distribution and density can be controlled. Rare earths can be made to preferentially partition into one phase or another. For example, it is possible to preferentially partition rare earth ions into the spectroscopically ideal halide phase. The oxide matrix provides a robust backbone which is chemically durable and easy to form and work. In such cases, it is truly possible to have the best of both worlds.

After a brief introduction on the structure and properties of multicomponent glasses, Prof. Houde-Walter will mention a few of the areas in which she has contributed to the science of optical glass.