Understanding 'glass relaxation' and why it's important for next-generation displays

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Next-generation displays will feature increased resolution and performance, but getting there will require a shift to smaller individual pixel sizes and a tightening of the tolerance for glass relaxation. Display manufacturers can account for a certain level of relaxation in the glass, referring to the intermolecular rearrangement, if it's known and reproducible. But fluctuations in this relaxation behavior tend to introduce uncertainty into the manufacturing process, possibly leading to misalignment of pixels within displays.

These fluctuations are caused by slight variations in the thermal history of the glass, and unfortunately no one has ever performed a systematic study of what governs fluctuations in the relaxation behavior of glass.

But now, this week in the *Journal of Chemical Physics* a research duo from Corning Inc., a glass manufacturer, and Qilu University of Technology in China, reports on a new modeling technique to quantify and predict glass relaxation fluctuations. Significantly, their study provides a better understanding of the physical origins of these fluctuations.

"Glass is a thermodynamically unstable material that continually relaxes toward the supercooled liquid state," said John Mauro, senior research manager of glass research at Corning Inc. "This relaxation is a spontaneous process that's accelerated during heat treatment."

Makers of flat-panel displays heat the glass to deposit the thin-film transistors for the display. Glass can relax during the heat-treatment process, and this relaxation typically involves a slight shrinkage in the volume of the glass. If uncontrolled, this shrinkage can lead to misalignment of pixels and a nonfunctioning display.

Qiuju Zheng, an associate professor at Qilu University of Technology, and Mauro are believed to be the first to explore the fluctuations in the relaxation behavior of glass by focusing on how much the magnitude of the relaxation varies due to slight thermal variations experienced by the glass—either during the initial glass formation or during the panel manufacturing process. Their work also has direct industrial relevance, whereby determining the parameters that control relaxation fluctuations should help guide future glass composition.

According to Mauro, the insights gained from this work are "already being put to use developing our next-generation glass substrates for high-performance displays." He also said, "There are many other properties of the glass that we're interested in, and this provides one important component for a larger set of models that we use to help guide the design and development of new high-tech glass compositions."

The researchers now look forward to addressing a remaining "big gap in building the connection between the physics of glass relaxation and the underlying glass chemistry," said Mauro.

The science of these glass relaxation effects center around subtle changes, typically measured in terms of parts per million of linear strain.

"Since these effects are so subtle, we still don't understand what's changing in the underlying glass structure to facilitate this relaxation in terms of which elements in the glass are undergoing slight rearrangements in bond configurations, and why," Mauro said. "Building this bridge between glass physics and glass chemistry is the next grand challenge that we should undertake."

More information: "Variability in the relaxation behavior of glass: Impact of thermal history fluctuations and fragility," *Journal of Chemical Physics*, DOI: 10.1063/1.4975760

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