Experimental Verification of Metallic Glass Prediction from Liquid Data

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Unlike ordinary metals with crystalline atomic arrangement, metallic glasses or
amorphous alloys, have a disordered atomic arrangement with local order extending to
nearest and next-nearest neighbors only. From a practical standpoint metallic glasses
have many desirable technological advantages over normal, crystalline, metals that
make them of potential commercial and military interest. They are much stronger than
normal metals and can be processed into intricate shapes using techniques that are
similar to those used to prepare polymeric materials. However, the process of metallic
glass formation and of how a liquid transforms into a glass (the glass transition) are
incompletely understood. Our goal is to go beyond the trial and error methods commonly
used to predict whether a liquid can make a good glass, and to devise an algorithm for
identifying good glass formers that does not require measuring $T_g$ (the glass transition
temperature) beforehand.

We propose that the critical casting thickness ($d_{\text{max}}$), which is a glass forming ability
indicator, is correlated with $T_{g}$ and $T_g/T$. Based on this we can derive a predictive
formula for glass formation. Further, we have shown that $T_g/T^*$, $T_g/T_A$, and the liquid
expansion coefficient are correlated with $T_g$. This allows us to predict $T_g$ before making
any glass; it can be predicted based on only the liquid data. Using the predicted $T_g$ and
the correlation between $\log (d_{\text{max}}^* d_{\text{max}})$, $T_{g}$, and $T_g/T^*$, glass formability can be predicted
from liquid data alone. Our work will tell us whether our predictive algorithms are
capable of pointing to good glass formers and, if so, giving an accurate value for $T_g$, using
only data from the high temperature liquid. Our studies of adding element to destroy the
icosahedral structure in alloys will also tell us whether the predictive algorithm needs to
correct for a liquid structure term.