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Metallic glasses: A type of promising energetic materials

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Metallic glasses are "born" upon cooling alloy melts fast enough to avoid crystal nucleation. Through glass transition, these glasses naturally inherit their mother liquids' structures, thus realizing the sampling of relatively high-energy, local minima or inherent structures of the potential energy landscape. Their crystalline counterparts, by contrast, reside in the global minimum of landscape with the lowest potential energy. Intriguingly, metallic glasses can have their affluent energy further enhanced via various rejuvenation methods [1], along with remarkable tuning of their mechanical and physical properties. The highly energetic feature of metallic glasses has long aroused abroad interest. For example, at the moment of fracture, violent sparking or intense light emission was often observed for the Zr-based bulk metallic glasses [2], accompanied by flash temperatures up to several thousand degrees. Similar phenomena were also observed during high-speed machining [3] or hypervelocity impact [4], suggesting that fractoemission of light in metallic glasses is associated with pyrolysis or oxidation of fresh material exposed during rupture in air. For this type of glassy metals, at what level is their combustion heat indeed? Are they promising candidates to serve as energetic materials?

The paper entitled "Highly energetic and flammable metallic glasses" [5] by Prof. Weihua Wang and colleagues envisions an exciting prospect for energetic applications of some metallic glasses with reactive elements. Through combustion experiments of a variety of metallic glass ribbons including Al-, Mg-, La-, Ce-, Zr-based systems, the combustion heat of many metallic glasses has been demonstrated to be approximately twice that of conventional non-metallic energetic materials like TNT and RDX. Compared with crystalline metallic nanoparticles, the metallic glass ribbons show a similar level of energetic performance, but at much lower ignition temperatures. In terms of the intermediate trade-off between combustion heat and ignition temperature, these metallic glass ribbons have huge potentials to be energetic materials. Last, but not least, their productivity, cost and safety surpass those of both non-metals and metallic nanoparticles.

This work provides a new energy dimension for applications of metallic glasses. Motivated by this breakthrough, future studies should focus on the following aspects: first, to deeply understand the fundamental structural and chemical processes associated with metal combustion; second, to develop effective methods such as high-throughput screening and machine learning for seeking metallic glass materials or structures with higher energetic and combustible performance; third, to promote the applications of highly energetic metallic glasses in defense or industry.

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