Self-propagating high temperature synthesis for compound thermoelectrics and new criterion for applicability of combustion processing

XINFENG TANG, XIANLI SU, Wuhan University of Technology, CTIRAD UHER, University of Michigan, TANG’S GROUP TEAM, UHER’S GROUP TEAM — Here we report compound thermoelectric materials (Bi$_2$Te$_3$, Bi$_2$Se$_3$, Cu$_2$Se, Cu$_2$SnSe$_3$, half-Heusler alloys, lead chalcogenides, skutterudites, and magnesium silicides) with thermoelectric properties comparable with materials prepared by the traditional routes of synthesis can be synthesized at a minimal cost and on the time scale of seconds using the self-propagating high temperature synthesis method. Moreover, we found that the criterion often quoted in the literature as the necessary pre-condition for combustion synthesis, $T_{\text{ad}} \geq 1800$ K, is not universal and certainly not applicable to thermoelectric compound semiconductors. Instead, we offer new empirically-based criterion, $T_{\text{ad}}/T_{\text{m,L}} > 1$, i.e., the adiabatic temperature must be high enough to melt the lower melting point component, which covers all materials synthesized by self-propagating high temperature synthesis, including the high temperature refractory compounds for which the $T_{\text{ad}} \geq 1800$ K criterion was originally developed. Our work opens a new avenue for ultra-fast, low cost, mass production fabrication of efficient thermoelectric materials and the new criterion greatly broadens the scope of materials that can be successfully synthesized by self-propagating high temperature synthesis.

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