NANOTECHNOLOGIES

UTAustin Portugal

Self-organised binary nanocrystal superlattices for next generation thermoelectrics

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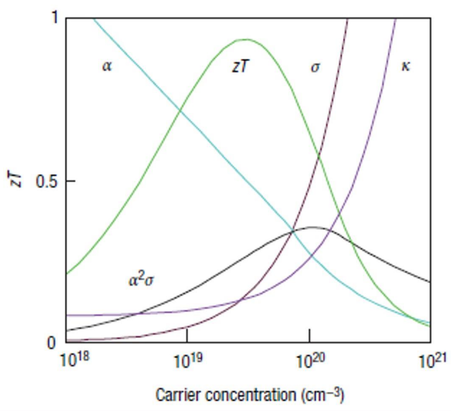
Background

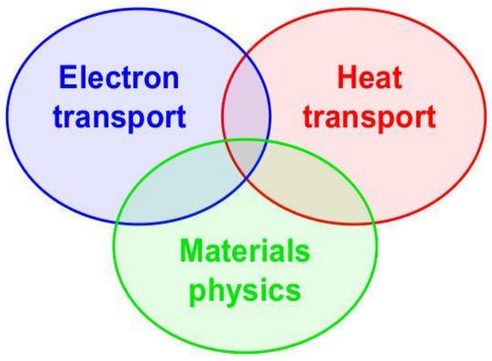
This work is a part of ongoing UT Austin-Portugal project “UT-BORN-PT: Unconventional Thermoelectrics based on Self-Organized Binary Nanocrystal Superlattices”. The proposed work comprises the objectives of understanding the thermal and electrical transport in highly ordered and stable nanocrystals (NCs) ensembles for high thermoelectric figure of merit attained via controlled structure and compositions.

A

$$\eta = \frac{\Delta T}{T_h}\frac{\sqrt{1+ZT}-1}{\sqrt{1+ZT}+\frac{T_c}{T_h}} \qquad ZT = \frac{\sigma\alpha^2 T}{\kappa}$$



B

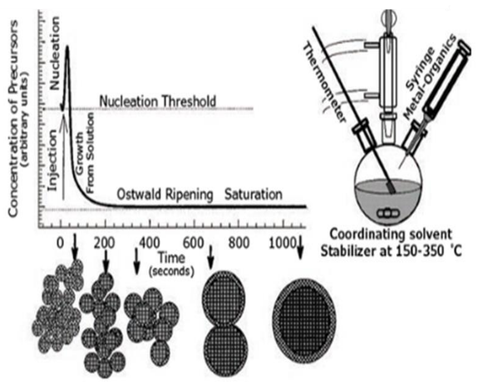


Snyder et al. Nature Materials 7, 105-114 (2008)
Murphy et al. JACS, 128(10), 3241-3247)
Urban et al. JACS, 128(10), 3248-3255

Methodology

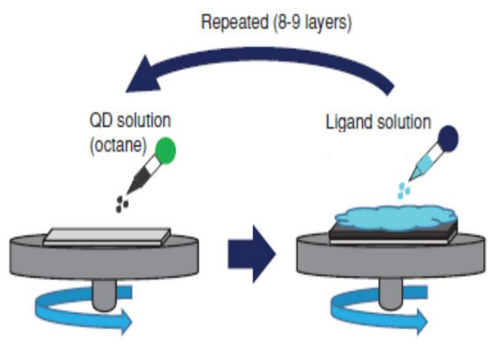
The chalcogenide quantum dots are synthesized using hot injection method as shown in Fig C by using suitable precursors. The binary nanocrystals superlattices as shown in Fig D, is fabricated by spin coating the CQD solution over the insulating SiO_2 layered Si substrate and performing the ligand exchange repeatedly for every layer deposition. The samples will then be examined for thermoelectric measurements to determine the ZT.

C



Colloidal QDs synthesis by Hot Injection Method

D



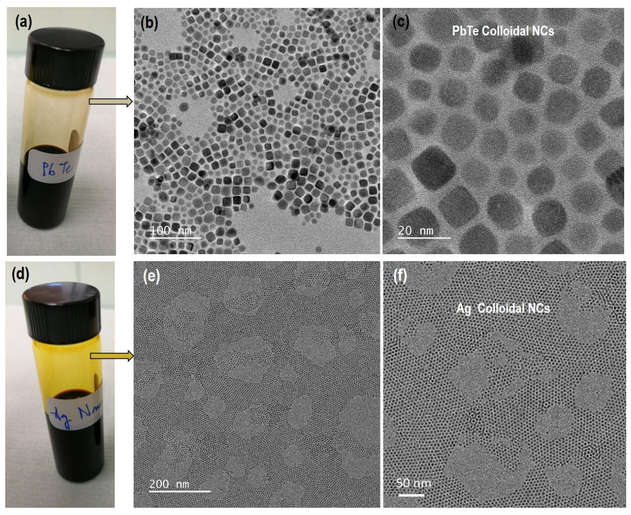
Spin Coating for Fabrication of Binary Nanocrystal Superlattices

Nugraha et al. Adv. Energy Mater. 2019, 1803049

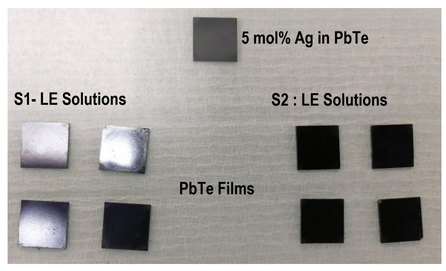
Preliminary Results

Figure E shows PbTe and Au CQDs solutions along with their microstructural TEM characterization. Fig F shows synthesised PbTe and PbTe-5 mol% Au films prepare by two different ligand exchange solution for thermoelectric measurements. The Saturated solutions comprises S1 ($Pb(NO_3)_2$ in MeOAc) and S2 (Ethylene diamine: Acetonitrile).

E



F



Ligand Exchange Solution (S1) : ($Pb(NO_3)_2$ in MeOAc)

Ligand Exchange Solution (S2) : Ethylene diamine in Acetonitrile

Conclusions

Self-organized binary nanocrystal superlatices (BNSLs) based on semiconducting colloidal nanocrystals addresses the prevailing needs in thermoelectric research for facile fabrication which is solution-processable, and transport property optimization for high conversion efficiency.

The unique combination of transport properties attained by proximal interaction, ligand engineering and nanostructuring in synthesized nanocrystal ensembles will provide fundamental breakthrough for simple, scalable and low-cost processing of high performance thermoelectric devices for practical applicability as energy harvesting device, particularly in rapidly growing wearable electronics market.

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INL INTERNATIONAL IBERIAN NANOTECHNOLOGY LABORATORY