

## **Spark Plasma Sintering of Oxide Dispersion Strengthened Alloys**

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Oxide dispersion strengthened (ODS) alloys are among the most promising candidates for advanced reactor concepts that require higher operating temperatures and irradiation doses. ODS alloys show very high strength, high temperature creep resistance, and highly resistant to irradiation induced damage such as swelling and hardening when uniform dispersion of very fine (1-2 nm) oxide particles and ultrafine grain size obtained such as in 14YWT. However, nuclear reactor applications require complex geometries that require welding. Conventional fusion welding techniques result in significantly altered microstructure (coarsening of particles, change in grain size) due to melting. Moreover, most ODS alloys have a highly alloyed matrix which makes it difficult to fusion weld. On the other hand, solid state welding techniques such as friction welding, diffusion welding, brazing, etc. were tested with some success. Spark plasma sintering, previously successfully used by us for the consolidation of ODS alloys, is also one of the promising techniques for joining of ODS alloys. The SPS-Joining technique involves application of rapid heating, external pressure, and possible passing of pulsed electric current through the material interface subjected to joining. In this study, SPS was successfully applied to join ODS alloy at different temperature and pressure. We used nanoindentation and electron microscopy to characterize SPS joints. Initial investigations indicate uniform properties across the joints. Successful implementation of the SPS joining testing of the joints will remove a major obstacle and allow wide range use of ODS alloys in nuclear applications.

# Control of Crystallization and Microphase Separation of Fully Conjugated Block Copolymers by Random Copolymers

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Donor–acceptor fully conjugated block copolymers consisting of electron donor and acceptor conjugated polymers are interesting as single-component active-layer materials for solar cells because it can adopt mesoscale microphase separated structures with length scales comparable to the exciton diffusion length. Nevertheless, due to the strong crystallization of poly(3-hexylthiophene-2,5-diyl) (P3HT), morphologies of fully conjugated block copolymers containing P3HT are predominantly driven by crystallization as opposed to microphase separation. We control the crystallization to promote microphase separated structures in fully conjugated block copolymers through the addition of small amounts of 3-octylthiophene to the polymerization of P3HT. Poly(3-hexylthiophene-2,5-diyl-*r*-3-octylthiophene-2,5-diyl)-*block*-poly((9,9-dioctylfluorene-2,7-diyl)-*alt*-(4,7-di(thiophene-2-yl)-2,1,3-benzothiadiazole)-5',5''-diyl) (P3HT-*b*-PFTBT) copolymers were prepared by Grignard metathesis followed by chain extension through a Suzuki-Miyaura polycondensation. We demonstrate that a fully conjugated block copolymer incorporating a random copolymer can control crystallization and microphase separation, in result, lead to enhanced performance in solar cell devices.

# Lead Selenide Quantum Dots for Use in Solid-State Radiation Detectors

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## *Abstract*

The unique optical and electrical properties of lead selenide (PbSe) quantum dots (QDs); which are due to quantum confinement effects that are a product of their nanometer scale sizes, have made PbSe QDs an interesting material for various devices from solar cells to photodetectors. Here we aim to leverage another important property, the high Z number of the material, to fabricate solid-state radiation detectors for high energy waves such as x-rays and gamma-rays. PbSe QDs are prepared using colloidal synthesis techniques which employ a weakly binding oleylamine ligand as the stabilizing ligand, for the purpose of fabricating a solid-state radiation detector using PbSe QDs as both the blocking and detection layers. Using oleylamine rather than the more traditional strongly binding oleate ligand allows for the facile in-solution ligand exchange with shorter anionic ligands. QDs passivated with shorter ligands are then implemented into testing devices (such as FETs, capacitors, and simple photodetectors) by spin-coating the colloidal solution into films. Thicker films, which are necessary for attenuation of x-rays and gamma-rays, can be fabricated by using more concentrated solutions and slower spin speeds; without the need for additional layer-by-layer ligand exchange steps, which has hampered and prolonged the fabrication time of thick QD films in the past. Data collected from research devices, such as carrier mobility and carrier capacity, is then used to calculate the performance and assess the feasibility of PbSe QDs as a material for use in low-cost solution processed solid-state radiation detectors.

*Key Words: colloidal synthesis, PbSe, quantum dots, radiation detection*