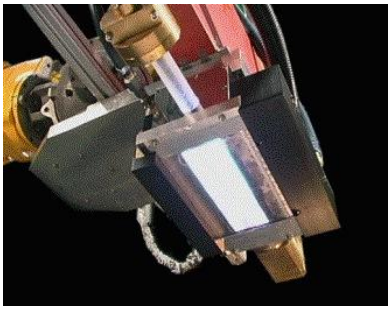
Pulse thermal processing (PTP) technology for rapid thermal annealing of thin-films

ORNL has developed a unique high-density plasma arc-based pulse thermal processing (PTP) technology for rapid thermal annealing of nanostructured thin-films. Nanostructured materials are rarely synthesized with appropriate phase and/or morphology. This technology addresses critical additional steps of as-synthesized nanostructured materials, such as annealing, phase transformation, or activation of dopants, dramatically reducing the processing costs of the thin film materials, including those in the area of solid-state lighting and photovoltaic. The unique high-density plasma arc lamp PTP capability allows controlled manipulation of materials on the atomistic scale. The unique large-area (up to ~1,000 cm^2) PTP capability is able to apply controlled heat fluxes (up to 20,000 W/cm^2) to material surfaces with heating and cooling rates on the order of 10^4 to 10^6°C/s within milliseconds. Thus, the current small batch size limit, very small areas of several mm^2, which are inherent to laser techniques, was removed by the PTP technology. As a result, direct evaluation of nucleation and growth events as a function of time and temperature is possible at a reduced cost. This process has the potential to significantly increase photovoltaic (PV) collection efficiency and LED electrical properties, while increasing production rates and decreasing production costs. PTP is able to process thin-film materials at elevated temperatures on flexible substrates, including polymers, with little or no effects on the substrate.



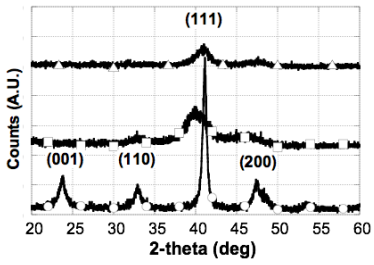
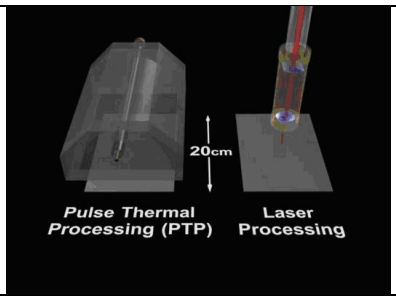


Figure 1: Plama arc lamp and X-ray diffraction patterns of (o) conventional furnace annealed FePt, (□) as-synthesized FePt, and (▽) PTP processed FePt exposed to five pulses of 400 Amps for 100 ms. The results indicated that the PTP sample show partial FCC to FCT phase transformation.



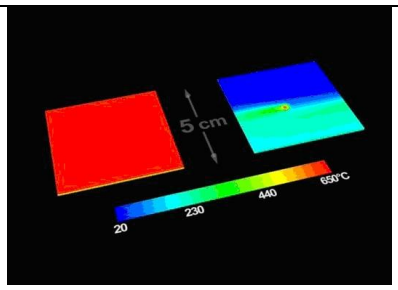


Figure 1: Temperature profile comparison for PTP versus laser processing.

Xu, J., Ott, R; Sabau, A.S. Pan, Z.; Xiu, F.; Liu, J.; Erie, J-M.; Norton, D. P., Appl. Physics Letters, 2008, Vol. 92, no. 15, pp. 151112.
Sabau, A.S. Kadolkar, P.B., Dinwiddie, R.B., Ott R.D., and Blue, C.A., Met. and Mat. Trans. A, 2007, Vol. 38A, pp. 788-797.
Patents/commercialization: Several patents were granted and technology was licensed to NovaCentrix
Contributing Agency: DOE