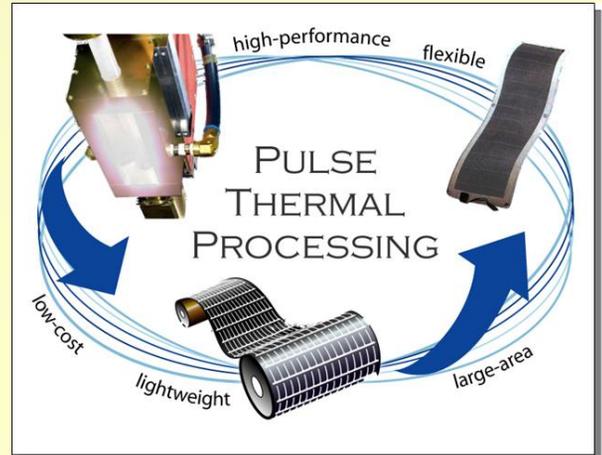


Pulse Thermal Processing (PTP) - Enabling Technology for Manufacturing High Performance, Low-Cost Photovoltaics

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Three generations of PV materials

- **Current: Polycrystalline silicon**
 - Efficiencies – 13% to 15%
- **2nd Generation: Thin-film materials**
 - Amorphous silicon, copper indium gallium diselenide, and cadmium telluride
 - Efficiencies – 5% to 11%
- **3rd Generation: Nanoparticle materials**
 - Graetzel cell – TiO₂ nanoparticles
 - Screen printing and sintering of nanoparticles
 - Efficiencies – 5% to 8%

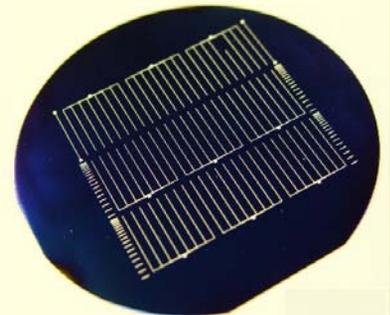


PTP can have an impact on all 3 PV generations

Current Generation

- **Poly-Si based PV systems with SiN_x anti-reflective coating**
 - Contains ~20% hydrogen
- **Front and backside contacts**
 - Screen printing front- and back-side contacts
- **PTP can provide orders of magnitude greater heating rates and much higher temperatures in order to remove hydrogen and achieve better front- and back-side contacts**

Poly-Si wafer
solar cell
specimen

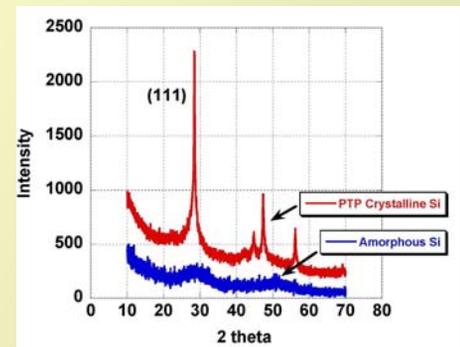


2nd Generation

- **Grain boundary refinement of crystalline materials**
- **Example: thin-film based PV on flexible substrates**
 - Copper indium gallium diselenide (CIGS)
- **PTP can provide rapid grain boundary refinement while minimizing diffusion within grains and no loss of selenium**
- **Crystallization of amorphous silicon**
 - Post deposition crystallization of *a*-Si is easier and cheaper to fabricate than poly-Si
- **PTP post deposition anneal is able to solid-phase crystallize *a*-Si**
 - Potential to process on flexible substrates due to large heating rates



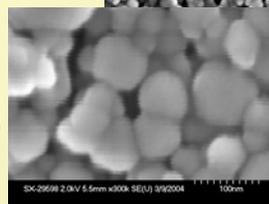
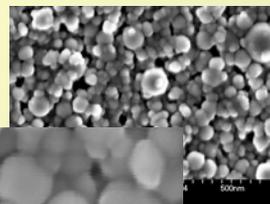
Portable PV power pack



XRD result of PTP solid-phase crystallization of *a*-Si on glass substrate

3rd Generation

- **TiO₂ nanoparticle based systems on flexible substrates**
 - Partial sintering to achieve “sponge-like” structure
- **PTP achieved sintering of nanoparticles without effecting the polymer substrate**



TiO₂ nanoparticles processed on polymer substrate