

## New Tool Quantitatively Maps Minority-Carrier Lifetime of Multicrystalline Silicon Bricks

NREL's new imaging tool could provide manufacturers with insight on their processes.

Scientists at the National Renewable Energy Laboratory (NREL) have used capabilities within the Process Development and Integration Laboratory (PDIL) to generate quantitative minority-carrier lifetime maps of multicrystalline silicon (mc-Si) bricks. This feat has been accomplished by using the PDIL's photoluminescence (PL) imaging system in conjunction with transient lifetime measurements obtained using a custom NREL-designed resonance-coupled photoconductive decay (RCPCD) system.

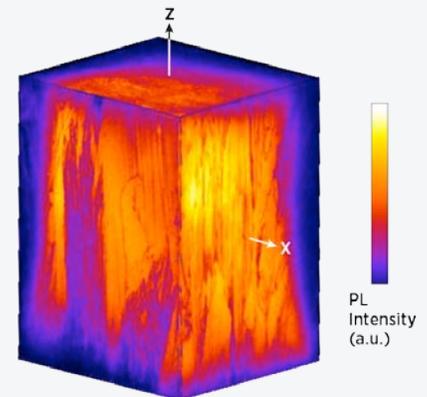
PL imaging can obtain rapid high-resolution images that provide a qualitative assessment of the material lifetime—with the lifetime proportional to the pixel intensity. In contrast, the RCPCD technique provides a fast quantitative measure of the lifetime with a lower resolution and penetrates millimeters into the mc-Si brick, providing information on bulk lifetimes and material quality. This technique contrasts with commercially available minority-carrier lifetime mapping systems that use microwave conductivity measurements. Such measurements are dominated by surface recombination and lack information on the material quality within the bulk of the brick.

By combining these two complementary techniques, we obtain high-resolution lifetime maps at very fast data acquisition times—attributes necessary for a production-based diagnostic tool. These bulk lifetime measurements provide manufacturers with invaluable feedback on their silicon ingot casting processes.

NREL has been applying the PL images of lifetime in mc-Si bricks in collaboration with a U.S. photovoltaic industry partner through Recovery Act Funded Project ARRA T24.

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**Reference:** S. Johnston, F. Yan, K. Zaunbrecher, M. Al-Jassim, O. Sidelkeir, and A. Blossie, "Imaging Study of Multicrystalline Silicon Wafers Throughout the Manufacturing Process," 37th IEEE Photovoltaic Specialists Conference, 19–24 June 2011, Seattle, WA.



*Photoluminescence imaging of a multicrystalline silicon block. The darker blue colors indicate potentially poorer quality areas with lower minority-carrier lifetimes.*

### Key Research Results

#### Achievement

NREL developed a new tool to quantitatively map minority-carrier lifetime of multicrystalline silicon bricks by using photoluminescence imaging in conjunction with resonance-coupled photoconductive decay measurements.

#### Key Result

Researchers are not hindered by surface recombination and can look deeper into the material to map bulk lifetimes. The tool is being applied to silicon bricks in a project collaborating with a U.S. photovoltaic industry partner.

#### Potential Impact

Photovoltaic manufacturers can use the NREL tool to obtain valuable feedback on their silicon ingot casting processes.