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Nonthermal plasma synthesis of nanomaterials for renewable energy applications

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ABSTRACT - Nonthermal plasmas offer unique conditions for the synthesis of nanomaterials. Molecular precursors are dissociated by electron impact reactions and the resulting molecular fragments and radicals, many of them charged, nucleate to form clusters and nanocrystals. Energetic surface reactions can heat these initial clusters to temperatures that exceed the gas temperature by hundreds of Kelvin. This enables plasmas to form crystalline nanoparticles of strongly covalently bound materials, many of which require high temperatures for crystallization. Moreover, different from colloidal syntheses that utilize organic solvents, plasma synthesis is fully conducted in the gas phase and as such much closer to "green chemistry."

This presentation will focus on the plasma synthesis of luminescent silicon nanocrystals as one example of the nanomaterials that can be successfully synthesized with plasmas. With the proper surface functionalization, silicon crystals exhibit strong photoluminescence, different from bulk silicon material, and have been studied in applications such as photovoltaics, light emitting devices, and bioimaging. We discuss that the specific optical properties of silicon nanocrystals with their strong absorption in the blue and emission in the red and near-infrared make them ideal candidates for solar luminescent concentration for photovoltaics integrated into buildings and with agriculture[1]. We also report on recent progress on multi-stage all-gas-phase processing of luminescent silicon particles, which involves a sequence of steps from the nanocrystal synthesis, to their surface functionalization, and gas phase annealing to improve optical properties.

[1] F. Meinardi, S. Ehrenberg, L. Dhamo, F. Carulli, M. Mauri, F. Bruni, R. Simonutti, U. Kortshagen, S. Brovelli, *Nat. Photonics* **2017**, *11*, 177.

Brief Bio

Uwe Kortshagen is professor of mechanical engineering at the University of Minnesota. He holds the Ronald L. and Janet A. Christenson Chair in Renewable Energy and is a Distinguished McKnight University Professor. His research is in the area of low temperature plasmas physics and chemistry and in the plasma synthesis of nanomaterials and their applications. He earned his Diploma degree in Physics in 1988, his Dr. rer. nat. (Ph.D.) in Physics in 1991, and his Habilitation in experimental physics in 1995 from the Ruhr University Bochum, Germany. He came to the U.S. in 1995 with a Lynen Fellowships of the Alexander von Humboldt Foundation and spent a year at the University of Wisconsin-Madison. In 1996, he joined the Department of Mechanical Engineering at the University of Minnesota as Assistant Professor, where he was promoted to Associate Professor in 1999, and to Professor in 2003. He served the Department as Director of Graduate Studies from 2006-2008 and as Department Head from 2008-2018. For his professional community, he served as President of the International Plasma Chemistry Society, as organizer of the 2002 Gaseous Electronics Conference, and as Chair of two Gordon Research Conferences. He is Fellow of the American Physical Society, the American Society of Mechanical Engineers, the Institute of Physics (UK), and the International Plasma Chemistry Society, and recipient of the 2015 Plasma Prize of the American Vacuum Society. He has directed several multi-investigator research teams, including a recent Army Research Office MURI project on “New Materials from Dusty Plasmas.” His work has been published in more than 200 journal articles, including papers in several *Nature* and *Science* family journals, *Nano Letters*, *Advanced Materials*, and *Physical Review Letters*. He holds 4 US patents.