# Epitaxial p-type Copper Iodide Thin Films with controlled Carrier Concentration grown by Pulsed Laser Deposition

Michael Lorenz[1]*

*e-mail: mlorenz@physik.uni-leipzig.de

[1] University Leipzig, Felix Bloch Institute for Solid State Physics, Semiconductor Physics Group, Leipzig, Germany

Copper iodide is a wide-bandgap, naturally p-type semiconductor with high transparency in the visible spectral range and high hole mobility up to 44 $cm^2/Vs$ [1]. Although sputtered CuI thin films using an external iodine vapour source reached unprecedented electrical p-type conductivity, and high rectification ratio of junctions with n-ZnO, and large Seebeck coefficient [2, 3], a wide-range control of the hole concentration as prerequisite for advanced device applications remains difficult.

Pulsed Laser Deposition (PLD) has proven to be a surprisingly simple and efficient growth method for high-quality CuI thin films with controlled hole concentration, without the requirement of an extra iodine supply [4]. Various doping concentrations for example with selenium could be obtained using one single elliptically segmented PLD target [5]. From a diffusion study of PLD CuI films with oxygen deficient or oxygen saturated $Al_2O_3$ capping layers we found evidence for oxygen being a dominant shallow acceptor in CuI films [6]. Single-crystalline CuI films with only one rotational domain could be in-situ grown using lattice-matched NaBr buffer layers on $SrF_2$(111) substrates [7]. Due to the high water solubility of NaBr, free-standing µm-thin CuI with high crystalline quality could be easily prepared by a simple lift-off strategy [8].

We acknowledge the support from the DFG Research Unit FOR 2857 “Copper Iodide as Multifunctional Semiconductor” within the years 2019 to 2025.

[1] Grundmann M, Lorenz M et al. Cuprous iodide – a p-type transparent semiconductor: history and novel applications. Phys. Status Solidi A 2013; 210(9): 1671-1703.
[2] Yang C, Kneiß M, Lorenz M and Grundmann M. Room-temperature synthesized copper iodide thin film as degenerate p-type transparent conductor with a boosted figure of merit. PNAS (Proc. Natl. Acad. Sci. U.S.A.) 2016; 113(46): 12929–12933.
[3] Yang C, Lorenz M, Grundmann M et al. Controllable Growth of Copper Iodide for High-Mobility Thin Films and Self-Assembled Microcrystals. ACS Appl. Electron. Mater. 2020; 2: 3627−3632.
[4] Storm P, Lorenz M et al. High mobility, highly transparent, smooth, p-type CuI thin films grown by pulsed laser deposition. APL Mater. 2020; 8: 091115; see also McConnon A. Researchers create highly transparent p-type copper iodide with enhanced electrical performance. AIP Scilight 2020; 391103-1.
[5] Storm P, Lorenz M et al. p-Type Doping and Alloying of CuI Thin Films with Selenium. Phys. Status Solidi RRL 2021; 2100214.
[6] Storm P, Lorenz M et al. Evidence for oxygen being a dominant shallow acceptor in p-type CuI. APL Mater. 2021; 9: 051101.
[7] Storm P, Lorenz M et al. Suppression of Rotational Domains of CuI employing Sodium Halide Buffer Layers. ACS Applied Materials & Interfaces 2022; 14(10): 12350-12358.
[8] Storm P, Lorenz M et al. Epitaxial Lift-Off of Single Crystalline CuI Thin Films. Journal of Materials Chemistry C 2022; 10: 4124 – 4127.