BAPVC Annual Project Report

Project Title: Thin Film Compound Semiconductor Solar Cells via Templated Growth
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Summary:

Combining normal Al-induced crystallization (AIC), a thin oxide layer, and rapid thermal annealing (RTA), MOCVD GaAs thin films having maximum grain size ~ 400 μm^2, with an areal coverage of 60% of the film by (100) grains were templated on crystallographically-textured poly-Ge films on glass substrates. The hole mobility of templated poly-GaAs films is similar to that of single crystal bulk GaAs at a similar doping level (~ 10^{18} cm^{-3}). Photoluminescence spectra at room temperature and 80 K measured from templated poly-GaAs films show strong band edge luminescence, indicating that defects resulting from the polycrystalline structure of GaAs are insufficient to suppress radiative recombination.

Key Accomplishments:

Large-grained (100) oriented poly-Ge thin film templates are achieved through normal AIC at relatively low annealing temperature, 250 ˚C, for 10 hours. Placing a thin layer of Al oxide between Al and a-Ge layers in the initial structure is critical to lower the required annealing temperature and shorten the annealing duration for layer exchange crystallization of Ge. In this study, RTA has proved to be effective to increase the Ge grain size in poly-Ge films after exchange. Combining normal AIC, a thin oxide layer, and RTA, the resulting poly-Ge thin films have grain sizes ≤ 124 μm^2, with an areal coverage of 57% of the film by (100) grains.

Poly-GaAs thin films seeded by poly-Ge templates have reasonably good crystal quality and electronic properties. The percentage of (100) grains in templated poly-GaAs film is > 60%, and the maximum single crystal grain size is ~ 400 μm^2. Such improved crystal quality compared with the poly-Ge template indicates the potential to further improve grain sizes and orientations by tuning the GaAs deposition recipe. Templated poly-GaAs thin films are p-type conductive, and the high hole doping is attributed to Ge atoms that dissolve in GaAs from the template. The hole mobility of templated poly-GaAs film (Figure 1) is as high as that in single crystal bulk GaAs at a similar doping level (~ 10^{18} cm^{-3}). Photoluminescence spectra (Figure 2) at room temperature and 80 K of templated poly-GaAs films show strong band edge luminescence, indicating that the defects resulting from the polycrystalline structure of GaAs are insufficient to suppress the strong radiative recombination.

Future Work:

Project completed; graduate student research assistant (Y. Li) completed her doctorate in Applied Physics.

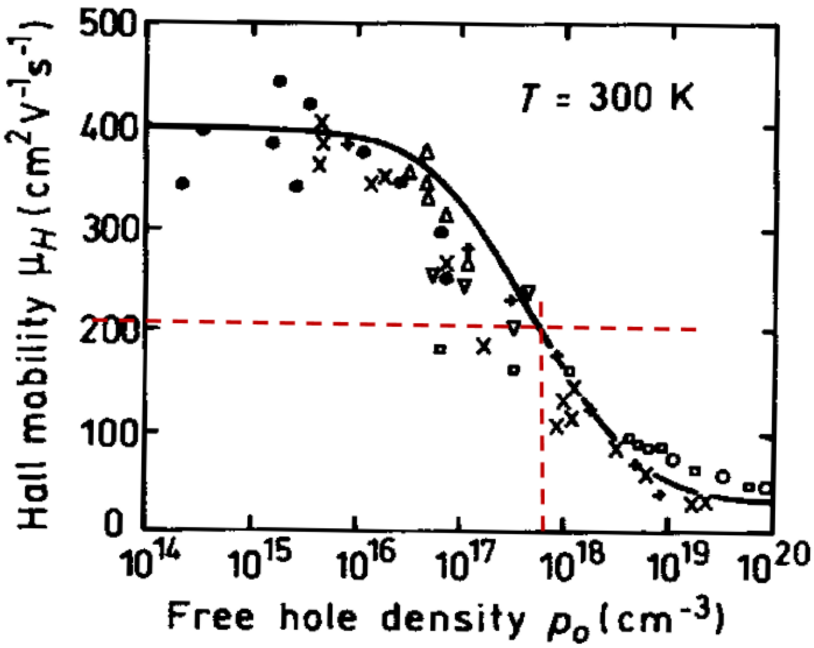

Figure 1 Hall mobility vs. hole density in single crystal bulk GaAs. The dashed line marks the hole density level of the poly-GaAs thin films seeded by poly-Ge template and their corresponding hole mobility.

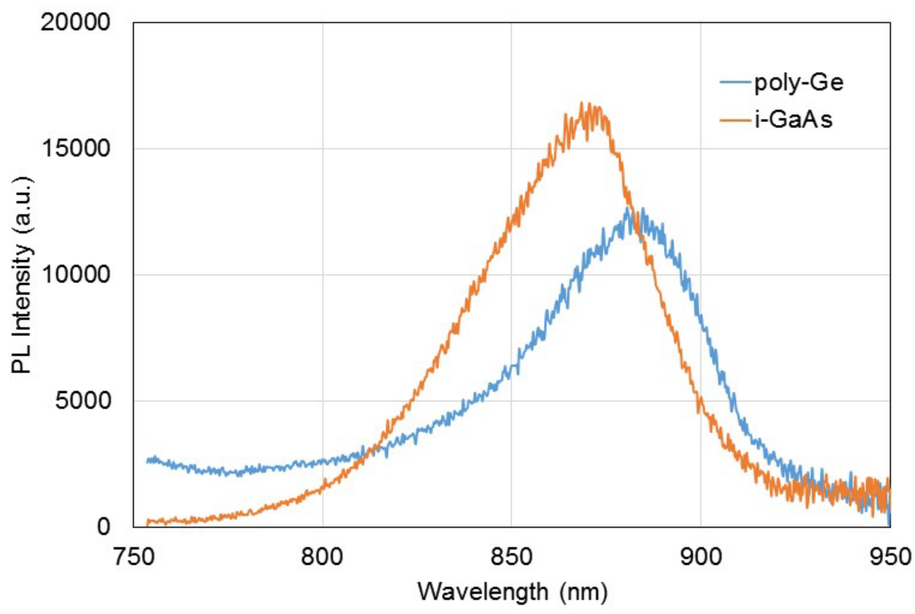

Figure 2 Photoluminescence spectra of a poly-GaAs film grown on a poly-Ge template and a GaAs film grown on a single crystal i-GaAs substrate measured at room temperature with the same incident power.