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High quality MgB$_2$ thin films in clean and dirty limit realized via HPCVD$^1$ CHENGGANG ZHUANG, SHENG MENG, QINGRONG FENG, ZIZHAO GAN, PKU P.R.C, HUAN YANG, YING JIA, HAIHU WEN, CAS P.R.C, XIAOXING XI, PSU USA — Pure and carbon-doped MgB$_2$ thin films are fabricated using hybrid physical-chemical vapor deposition. Excellent properties are obtained in the pure samples, including $T_c$ $\approx$ 41.4K, $\rho_{g}(42K)$ $\approx$ 0.3$\mu \Omega$ cm, which indicates that films are in the clean limit. Ultrahigh critical current density, up to 1x$10^8$A/cm$^2$ at 5K and zero fields, approaching the theoretical deparing current of MgB$_2$, was observed in a 150nm-wide microbridge, in agreement with the results derived using a Bean Model from the magnetization measurements. Large normal state magneto-resistance before the transition, about 40% at 7T, and absence of flux jump at low temperature and low field regions in the magnetization curves strongly support that the film is very clean. To enhance upper critical field and flux pinning, carbon doping is employed and realized in a dual-heater HPCVD setup from the thermal decomposition of CH$_4$. $\mu_0H_{c2}(0)$ $\approx$ 54T, $J_c(5K,6T)$ $\approx$ 3x$10^5$A/cm$^2$, as well as $T_c(0)$ $\approx$ 34K and $\rho_{g}(42K)$ $\approx$ 47$\mu \Omega$ cm are achieved in the carbon-doped films. By controlling the carbon concentration, MgB$_2$ films in dirty limit can be prepared.

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