Alloy Disorder Modulated Electron Transport at $Mg_xZn_{1-x}O$/ZnO Heterointerface

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Encouraged by the prospects of exciting physics, there has been a continuous demand to improve the quality of two-dimensional electron systems [1], necessitating the investigations of various disorders influencing the quantum transport. Among others, the two-dimensional electron gas (2DEG) at the $Mg_xZn_{1-x}O$/ZnO heterointerface has attracted attention for its high mobility outside the realm of conventional modulation doping concomitant to strong electron correlations, where the rapid progress in quality has been facilitated by optimization of ozone molecular beam epitaxy [2]. Here, we study the effect of short-ranged alloy disorder on the scattering of 2DEG by employing a modified interface profile consisting of $Mg_{0.01}Zn_{0.99}O$/ZnO with a thin (2nm) $Mg_xZn_{1-x}O$ interlayer with x ranging from 0.005 to 0.4. This interlayer design allows us to investigate scattering mechanisms at a nearly constant carrier density [Fig. 1(a)] but influence alloy disorder by altering the electron wave function penetration in to the MgZnO barrier layer. The effect of this design on heterostructure quality was studied by deducing the transport (τ_{tr}) and quantum (τ_q) scattering times, as extracted from the low-field mobility and Shubnikov-de Hass oscillations, respectively. While the τ_{tr} shows a strong correlation with x, τ_q remains insensitive to x [Fig. 1(b)]. The large variation in the τ_{tr} / τ_q ratio (from 16.2 to 1.5 corresponding to x from 0.005 to 0.4) implies a change in the dominant scattering mechanism from long range towards short range with increasing x. The insensitivity of τ_q on x indicates the scattering rate is not dominated by the alloy disorder but other scattering mechanisms, likely unintentional background impurities or remote surface disorders, providing a prospect for pursuing ever higher levels of 2DES quality in $Mg_xZn_{1-x}O$/ZnO system.

[1] L.N. Pfeiffer *et al.*, Physica E **20**, 57 (2003).
[2] J. Falson *et al.*, Sci. Rep. **6**, 26598 (2016).

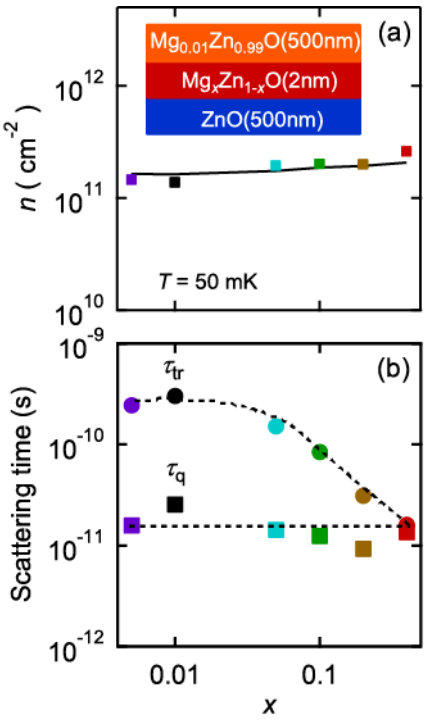

Fig. 1 Dependence of (a) the carrier density (n) and (b) scattering times (τ_{tr} and τ_q) on the x for the $Mg_{0.01}Zn_{0.99}O$(500nm)/$Mg_xZn_{1-x}O$(2nm)/ZnO(500nm) heterostructures at T =50mK.