Morphology of Porous Layer Formed Locally on n-InP (001) by Anodic Polarization in HCl after Scratching

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It is known that a porous layer is formed by anodic polarization in halogenic acids for not only Si but also compound semiconductors such as GaAs and InP. A porous semiconductor has large number of applications because visible luminescence is emitted mainly due to quantum confinement effect. The porous layer can be selectively formed only on the scratched area as pointed out by Schmuki *et al.* [1]. In this study, anodic polarization of n-type InP in HCl after scratching was performed to find the optimum condition for local formation of porous layer and observe the morphology of porous layer.

The materials used were n-type InP(001) wafers doped with 3.3 – 4.7 x 10^{18} cm^{-3} of sulfur. The ohmic contact for the backside of the wafer was made with annealing in nitrogen gas at 330-380 ^{o}C after the formation of successive layers (Au-Ge, Ni and Au) by a vacuum evaporation. The specimen (001) surfaces were scratched to the [110] and $[\bar{1}10]$ directions in air with a diamond scriber to draw ten scratched lines crossed each other and subsequently, anodically polarized at a constant potential for a certain time in deaerated 0.5 M HCl in dark. A light illumination during anodic polarization of n-type InP was not necessary for formation of porous layer since a tunneling breakdown occurred easily due to sufficiently high doping level of the specimens. The surface and cross sectional morphologies of intact and scratched areas after anodic polarization were observed with scanning electron microscopy (SEM).

Fig. 1 shows the potentiodynamic polarization curves measured at a sweep rate of 10 mV s^{-1} with anodic sweep from the potential of natural immersion (– 0.2 V) up to 3 V and then cathodic sweep down to – 0.2 V for the n-type InP wafers as received and scratched, respectively. The potential in the abscissa of Fig. 1 was referred to a standard hydrogen electrode (SHE). The as-received specimen has one anodic current peak at about 1.7 V in the anodic potential sweep, while the scratched specimen has the shoulder in the potential region between 0.8 V and 1.3 V in addition to the main anodic current peak. The presence of the anodic current shoulder for the scratched specimen indicates that the porous layer can be selectively formed on the scratched area by anodic polarization at the potentials significantly lower than the potentials for the formation of porous layer on the intact area. The selective formation of porous layer on the scratched area is mainly due to the local anodic dissolution from the defects produced by scratching.

Fig. 2 shows the typical SEM images of the InP specimen anodically polarized at 1.1 V for 300 s in 0.5 M HCl after scratching. It is seen from Fig. 2a) that the porous layer was selectively formed only on the scratched area. The cross sectional images along the dashed lines perpendicular and parallel to the scratched zone in Fig. 2 a) are shown in Figs. 2 b) and 2 c), respectively. Fig. 2 b) indicates that the porous layer (p.l.) has a reciprocal triangular shape in the cross sectional area corresponding to the $(\bar{1}10)$ plane. Fig. 2 b) also indicates that the crack generated due to scratching is extended to the inside of the substrate. In contrast, Fig. 2 c) indicates that the porous layer (p.l.) has the band shape in the cross sectional area corresponding to the (110) plane. The crystallographic structure of porous layer on the scratched area is similar to the etching profiles of the InP (001) chemically etched in HCl [2].

References

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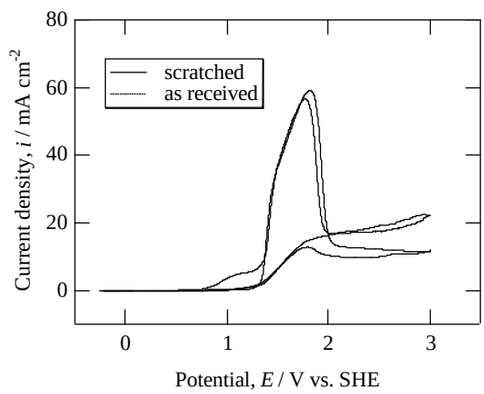

Fig. 1 Potentiodynamic polarization curves in 0.5 M HCl for the InP wafers as received and scratched, respectively.

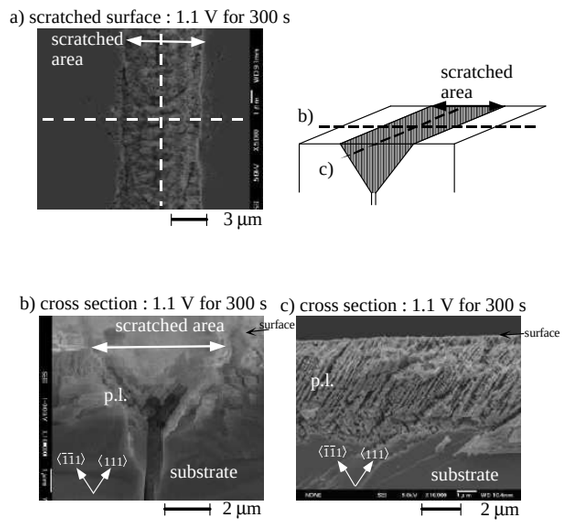

Fig. 2 SEM images of the InP specimen anodically polarized at 1.1 V for 300 s in 0.5 M HCl after scratching.