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Etch Mask Passivation and Etching of III/V Compounds by CO$^+$ Ion Beams

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Ion beam etching is a useful tool for pattern transfer into semiconductor substrates. Fabrication of optoelectronic devices with submicron features requires thin masks of extremely low sputter yield and shrinkage. Looking on ion etching as a kind of local evaporation, materials with high melting point and high heat of sublimation should be selected for etch mask purposes. On that score the oxides,nitrides and carbides of titanium,zirconium and hafnium are very promising candidates [1].

Thin films of these compounds can be formed by reactive sputtering or by reactive evaporation in a low pressure gas atmosphere [2]. However both methods are incompatibel with mask generation by lift off processing of an organic photo resist. This is due to all angle impingement of the deposited material in the former, due to high substrate temperature required for compound formation in the latter case. These difficulties can be circumvented by formation of a thin etch resistant compound layer on top of the metal mask by the ion etch process itself, a principle already applied by the author for structuring InP/InGaAsP mushroom type laser using N_2^+ ions in an H_2O ambient atmosphere [3]. Building up of nonstoichiometric titanium oxinitride is responsible for the extremely high etch selectivity against InP (etchrate InP/ etchrate Ti > 30) in this case.

In the present work CO$^+$ ion beam etching of InP and GaAs substrates masked by thin films of titanium and hafnium is studied. Due to formation of a shallow oxide-carbide layer sputter yields of the metal masks became extremely low. In this way an etch rate ratio InP/Hf > 100 is achieved for Hf on InP, the highest value published up to now. For InP and GaAs reasonable etch rates comparable to other non reactive ion etch processes are achieved. The etched surfaces remain mirrorlike smooth even for etch depth as high as 3μm. There is no indication of a local drop out of elementary carbon during etching with CO$^+$, usually a problem with other carbon containing gases.

Etch conditions and mechanism for mask and substrate material are discussed. Changes in the electronic surface properties of InP and GaAs due to the CO$^+$ etch process are investigated.

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