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Microwave-Induced Cleaving and Patternless Transfer of Semiconductor Films

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Intellectual Property Status

Patent Pending

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Background

Processes for building devices in heterogeneous systems, such as silicon on insulator (SOI) technology, are becoming increasingly popular, especially in light of the recent interest in employing novel heterostructures for use in flexible electronics and displays. Of the two leading processes, ion cut technology, which comprises implanting ions into a donor substrate and using an anneal to exfoliate a semiconductor layer from the donor substrate onto the carrier substrate, is generally superior to back etch silicon on insulator (BESOI) technology, which comprises etching away hundreds of microns of material in order to leave a thin layer of silicon on an insulator; specifically, ion cut technology tends to result in shorter process times and lower material inputs due to the reduction in process steps and the ability to reuse donor substrate material.

Notwithstanding these advantages, there still remain various limitations on existing process schemes. Present techniques rely on resistive heating until reaching average temperatures, typically around 400°C, and offer poor capability to determine required process times. Consequently, present techniques are unsuitable for thermally mismatched materials, thereby restricting existing technology to silicon-based and certain III-V compound-based semiconductor materials that are compatible with the high processing temperatures, and further, require approximations regarding process time. Moreover, both techniques demonstrate edge profile problems caused by dosage variations in the implant species resulting from the impeding film barrier.

Invention Description

Researchers at Arizona State University have developed an ion cut process that uses microwave radiation to induce exfoliation of a semiconductor layer from a donor substrate and/or using focused ion beam (FIB) implantation to selectively transfer a portion of the semiconductor layer. The user may tune the power and/or frequency of the microwave radiation in order to increase absorption efficiency within the volume of the donor substrate and/or to establish an exfoliation time.

Potential Applications

- **Fabrication of Novel Heterostructures** (e.g. Silicon on Insulator (SOI); Si-Ge on Insulator (SGOI); Strained-Si on Insulator (SSOI), etc.)
- **Fabrication of Flexible Electronics and Displays**
- **Defect Analysis Tool for Microelectronic Failure Analysis**

Benefits and Advantages

- **Allows Tuning of Power and/or Frequency of the Microwave Radiation** – provides capability to increase absorption efficiency within the volume of the donor substrate and/or to establish exfoliation time; exfoliation times as low as 12 seconds recorded (up to a 33% reduction compared to traditional exfoliation using co-implantation or non-co-implantation)
    - **Microwave Heating Allows Visual Monitoring of Procedure**
- **Provides for Usage of Any Suitable Carrier Substrate** – may include Si, SiGe, SiGe alloys, III-V substrates, III-V alloys, II-VI substrates, II-VI alloys
    - **Capability to Match Process Temperatures to Material Properties**