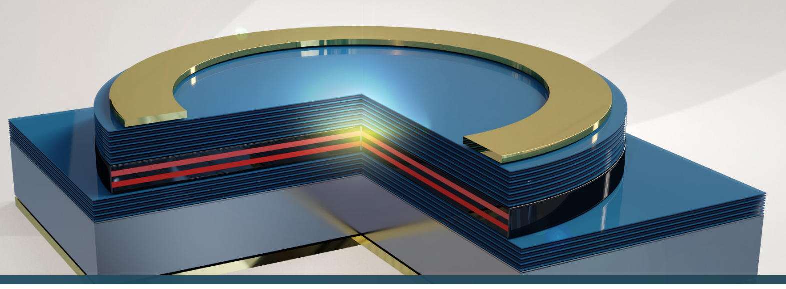

Factsheet 4: Fabrication Techniques for Germanium Photonics (Part 2)

Germanium photonics refers to the use of germanium as a material in photonic devices. Germanium is favoured due to its superior electronic and optical properties, such as high electron mobility and compatibility with silicon technology. This factsheet provides an overview of the key fabrication techniques employed in creating germanium-based photonic devices. Further fabrication technologies can be found in Factsheet 3.

Wet Etching

Wet etching involves the use of liquid chemicals to selectively remove material from a substrate. This technique is essential for bulk material removal and creating features with smooth surfaces. The substrate is cleaned and prepared to ensure proper adhesion and uniformity of the etch and then a protective mask (often a photoresist or metal layer) is applied to the substrate to define the areas to be etched. The substrate is immersed in or exposed to a chemical solution (etchant) that selectively reacts with and dissolves the exposed material and is then rinsed with deionized water to remove any residual etchant and reaction by-products.

Vapor Phase Etching

Vapor phase etching is a technique where gaseous reactants selectively remove material from a substrate. This method offers several advantages over liquid-phase etching, including reduced contamination and improved selectivity. The substrate is cleaned to ensure proper adhesion and uniform exposure to the etchant gases and is placed in a reaction chamber where it is exposed to a gaseous etchant. The etchant gas reacts with the exposed material on the substrate surface, forming volatile compounds and they are then removed from the reaction chamber, typically by a vacuum system. Once the etching process is complete, any remaining reaction products are evacuated from the chamber, and the substrate may undergo a final rinse with an inert gas to remove any residual chemicals.

Ion Implantation

Ion implantation involves the directed insertion of ions into a substrate to alter its physical and electrical properties. This technique is essential for doping semiconductors and modifying material characteristics. The desired dopant material is ionized to form positive ions and accelerated using an electric field to high velocities, providing the energy needed to penetrate the substrate. The accelerated ions are directed at the substrate, where they collide with and embed into the surface.

Annealing

Annealing is a thermal treatment to modify material properties, repair damage, and activate dopants. It is a critical step following processes like ion implantation, deposition, and etching. The substrate is heated to a specific temperature, which can range from a few hundred to over a thousand degrees Celsius, depending on the material and desired outcome.

- Rapid Thermal Annealing (RTA): RTA uses high-intensity lamps to quickly heat the substrate to the desired temperature for a short duration. The substrate is placed in a chamber and exposed to rapid heating and cooling cycles.
- Furnace Annealing: Furnace Annealing uses conventional furnaces to heat the substrate for longer durations. The substrate is placed in a furnace, heated to the desired temperature, held for a specific time and then cooled slowly.
- Laser Annealing: Laser Annealing utilizes laser pulses to locally heat the substrate, enabling precise control over temperature and area.

Metallization

Metallization is a vital process in microfabrication, enabling the creation of essential electrical and reflective components in semiconductor, photonic, and MEMS devices. By selecting appropriate deposition techniques and carefully controlling process parameters, high-quality metal films can be achieved, ensuring device performance and reliability.

- Physical Vapor Deposition (PVD): PVD involves the physical transfer of metal atoms from a source to the substrate. Ions from the plasma strike the metal target, dislodging atoms that then deposit onto the substrate. There are also two different types of PVD: Sputtering and Thermal Evaporation.
- With Sputtering, metal atoms are ejected from a target by bombardment with ions. The ions from the plasma hit the metal target and detach the atoms, which are then deposited on the substrate.
- With the Thermal Evaporation method, the metal is heated until it evaporates and then condenses on the substrate. The vaporized metal atoms migrate through the vacuum and condense on the substrate.
- Chemical Vapor Deposition (CVD): CVD involves the chemical reaction of vapor-phase precursors to form a metal film on the substrate. Metal-containing precursors are introduced into a reactor chamber and chemical reactions occur on the heated substrate, depositing a metal film.
- Electroplating: Electroplating uses an electric current to deposit metal from a solution onto a conductive substrate. The substrate (cathode) and a metal source (anode) are immersed in an electrolyte solution containing metal ions. An electric current is applied, causing metal ions to reduce and deposit onto the substrate.

Evaporation

Evaporation is a widely used physical vapor deposition (PVD). It involves heating a material until it vaporizes and then condenses onto a substrate to form a thin film. This method is essential for depositing metals, dielectrics, and other materials in microfabrication processes.

Germanium photonics fabrication involves a combination of advanced techniques including epitaxial growth, lithography, etching, doping, annealing, and metallization. Each technique plays a crucial role in the precise and efficient production of high-performance germanium-based photonic devices, paving the way for advancements in telecommunications, data processing, and sensor technologies.

Consortium
8 Partners
5 Countries

Budget
€ 4,8 Million
100% EU-funded

Duration
36 Months
10/2022 - 09/2025

Funded by the European Union under grant agreement no. 101102622. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.