Fabrication and Characterization of Thin Films in BaO-SrO-TiO_2 System Produced by a Photochemical Metalorganic Deposition Process

Shyama Mukherjee,[1] Harold Madsen,[1] Paul Roman,[1] Leo Svendsen,[1] Mike Fury,[1] Sean Barstow,[2] Augustin Jeyakumar[2] and Clifford Henderson[2]

[1]EKC Technology
2520 Barrington Court
Hayward, CA 94545
USA

[2]School of Chemical Engineering, Georgia Institute of Technology
778 Atlantic Drive
Atlanta, GA 30332
USA

The inclusion of metal oxides and mixed metal oxides processing higher dielectric constants than more traditional insulators such as silicon oxide into microelectronic devices is currently an important topic in a variety of areas. For example, the inclusion of embedded passive devices such as capacitors into printed wiring boards (PWB) is currently of considerable importance in the field of packaging technology for system-on- package (SOP) applications. However, the commercialization of this technology is being hindered due to a variety of issues including limitations in the types of dielectric materials and deposition processes that can be integrated with board manufacturing processes. Similar issues are being faced in passives integration for system-on-a-chip (SOC) technologies. The metal oxide deposition described in this work combines the ease of spin-on processing and direct photo patterning of a dielectric to overcome a number of limitations encountered with other dielectric deposition methods. The process described in this work has the advantage that requires low temperatures (¡300C) and does not require the use of plasma etching to achieve pattern definition. These capabilities allow the process to be more easily integrated with processes requiring low temperature, low cost processing such as those found in PWB fabrication using polymeric substrates. The fabrication of photodefineable high dielectric constant thin films at low temperatures has broader implications in simplifying the processing of high-k thin films for various other applications as well. The present work describes the photochemical deposition of fine patterned thin films in the BaO-SrO-TiO_2 system. Thin films of spin-coated metalorganic solutions have been patterned by conventional UV lithographic exposure using chrome on quartz masks. The unexposed portions of the film are dissolved using organic solvents as developers. The photoconversion process for thin films of these materials has been monitored by ellipsometry,FT-IR and thermal desorption mass spectroscopy. Film stress in metal oxide films produced has been determined as function of processing conditions, film thickness and post conversion thermal cycling using wafer curvature methods. The dielectric constants as a function of film composition, processing conditions and post-conversion thermal processing have been determined at MHz and at GHz frequencies he inclusion of metal oxides and mixed metal oxides processing higher dielectric constants than more traditional insulators such as silicon oxide into microelectronic devices is currently an important topic in avariety of areas. For example, the inclusion of embedded passive devices such as capacitors into printed wiring boards (PWB) is currently of considerable importance in the field of packaging technology for system-on- package(SOP)applications. However,the commercialization of this technology is being hindered due to a variety of issues including limitations in the types of dielectric materials and deposition processes that can be integrated with board manufacturing processes.Similar issues are being faced in passives integration for system-on-a-chip(SOC) technologies. The metal oxide deposition described in this work combines the ease of spin-on processing and direct photo-patterning of a dielectric to overcome a number of limitations encountered with other dielectric deposition methods. The process described in this work has the advantage that requires low temperatures(¡300C) and does not require the use of plasma etching to acheive pattern defination. These capabilities allow the process to be more easily integrated with processes requiring low temperature, low cost processing such as those found in PWB fabrication using polymeric substrates.The fabrication of photodefineable high dielectric constant thin films at low temperatures has a broader implications in simplyfying the processing of high-k thin films for various other applications as well. The present work describes the photochemical deposition of fine patterned thin films in the BaO-SrO-TiO_2 system. Thin films of spin-coated metalorganic solutions have been patterned by conventionalUV lithographic exposure using chrome on quartz masks.The unexposed portions of the film are dissolved using organic solvents as developers. The photoconversion process for thin films of these materials has been monitored by ellipsometry,FT-IR and thermal desorption mass specroscopy. Film stress in metal oxide films produced has been determined as afunction of processing conditions, film thickness and post conversion thermal cycling using wafer curvature methods. The dielectrc constants as a function of film composition, processing conditions and post-conversion thermal processing have been determined at MHz and at GHz frequencies.