Silicon oxide has been used as a gate dielectric material for over 40 years, but as transistor dimensions shrink, alternatives with higher dielectric constants are needed to reduce leakage currents. High-k dielectrics like HfO2, ZrO2, Al2O3, and others have been investigated for their thermal stability and compatibility with Si. FinFET technology, with 3D double-gate transistors, has further advanced, leading to smaller, more efficient transistors with reduced power consumption. DOI: 10.12693/APhysPolA.136.873

The continuous downscaling of MOS devices is essential for increasing transistor density and performance, leading to efficient chip functionality at higher speeds. However, this scaling poses challenges such as severe short channel effects (SCEs), increased fabrication costs, and difficulties in device processing. Multi-gate MOS device structures like FinFETs, which use multiple gate electrodes and an ultrathin body, have been developed to address these challenges, showing excellent device performance at scaled parameters. An important aspect of FinFET structures is threshold voltage tuning and its sensitivity to different device parameters. Studies have shown that threshold voltage is insensitive to doping variation in nanoscale MOSFET structures, leading to a preference for engineering the work function of gate materials rather than increasing body doping. The use of metal gates has become attractive due to their chemical stability with high-k gate dielectrics and the ability to maintain higher threshold voltages while acquiring high gate stack stability. tp://dx.doi.org/10.4236/wjnse.2013.31003

Functionally graded materials (FGMs) are composite materials with a continuously variable distribution of two or more constituent phases [6]. The composition and/or microstructures of FGMs change gradually, resulting in a graded pattern of material properties. FGMs have applications in various fields such as structural materials, biomaterials, semiconductors, coating materials, and electrode materials [7]. FGMs eliminate sharp interfaces between different materials and instead have a gradual variation from one material to another [8] FGMs are inhomogeneous materials whose properties change continuously with spatial positions [9]. The manufacturing of FGMs can be achieved through different techniques, including additive manufacturing (AM), physical vapor deposition, chemical vapor deposition, powder metallurgy, and centrifugal casting [10], [11]. ~~FGM grading is achieved by controlling the distribution of certain properties within the material.~~ FGM grading can be either discrete or continuous, and this gradient can relate to material composition, orientation, or the proportion of different phases [12]. In case we have a discrete profile grading we can have a stepwise profile. In the case of continuous profile grading, we can have either a linear profile, where the material properties change linearly from one surface to the other, or a profile that follows an exponential, nth-power, or sigmoidal pattern, resulting in a smooth transition of material properties that can be represented by functions such as the hyperbolic tangent function. ~~There might exist many phases of the materials neighboring each other so that as thickness is varied the material property changes from phase A to phase B which means that this is single FGM. As material A concentration increases the other material B concentration decreases. In a double FGM, there are 3 seperate materials or phases so that while thickness changes, material property is gradually varied starting with A emerging into B and fully ending up in C. In this work, we performed simulations with single and double FGM dielectric materials for trigate FinFET structure.~~

Our research focused on conducting simulation-based studies of FinFETs ~~since their introduction in the year 2000 [13],~~ performance of FinFET technology, including analytical modeling and simulation of FinFET devices ~~[14],~~ the influence of fin geometry on corner effects in multifin dual and tri-gate SOI-FinFETs ~~[15],~~ benchmarking of FinFET, nanosheet, and nanowire FET architectures for future technology nodes [16], the analog performance analysis of stacked oxide top-bottom gated junctionless FinFET [17] and a detailed study of single-material gate, double-material gate, and triple-material gate FinFETs were carried out [18]. In-depth analysis of typical types of FinFETs were presented in [19] with which we tried to match the terminology and abbreviations within that paper.