TITLE: Advanced Solid State Sensor Technology Base for Vision 21 Systems

AUTHORS: [1]C.D. Stinespring and [2]K. Meehan
STUDENTS: [1]C. Peng and [3]A. Woodworth
ADDRESS: [1]Department of Chemical Engineering
West Virginia University, Morgantown, WV 26506-6102
[2]Bradley Department of Electrical and Computer Engineering
Virginia Polytechnic Institute and State University, Blacksburg, VA 24060
[3]Department of Physics
West Virginia University, Morgantown, WV 26506
PHONE: 304-293-2111x2425
FAX: 304-293-1439
EMAIL: cstinesp@wvu.edu
GRANT NO.: DE-FG26-01NT41237
DURATION: 2001-2004

1. ABSTRACT

Program Rationale

This research is aimed at the development of an integrated sensor for gas species and temperature based on commercial 6H-silicon carbide (SiC) semiconductor technology. SiC is a high temperature, wide band gap semiconductor with exceptional chemical and thermal stability. As a consequence, research over the past decade has been aimed at the development of SiC for high temperature electronics and gas sensors. Based on extensive studies of Schottky diode and metal-oxide-semiconductor (MOS) device structures, the major problems facing SiC sensors can be traced to long-term thermal degradation of sensor performance due to intermixing and reaction at the metal-semiconductor interface.

Objectives

The objective or our research is to improve of thermal stability of the metal-semiconductor interface by improving the quality of the 6H-SiC surface. In these studies, ultrahigh vacuum deposition techniques are being used that can readily be incorporated into prototype sensor fabrication processes. These fabrication methods are combined temperature dependent electrical characterization studies. As a result of this approach, we are in a unique position to monitor and document each step of the device fabrication process and to relate these data to device characteristics and performance.

Accomplishments to Date

In the presentation, we will describe the experimental approach and accomplishments to date in detail. Specifically we have developed a scalable process for reproducibly producing periodically stepped 6H-SiC surfaces. This process uses standard wet chemical etching and high temperature hydrogen annealing. The resulting substrate surfaces are characterized by ~100 nm wide terraces and ~1.5 nm high steps (for on axis substrates). These stepped surfaces produce metal-semiconductor interfaces that are much more thermally stable than those fabricated on substrates prepared with standard wet chemical etching alone. Moreover, it is shown that when metal-semiconductor interfaces formed on the stepped surfaces do become unstable and react to

form silicides, the transport mechanisms are much different than those for the standard substrate preparation. As a result, the surface composition and morphology are completely different. This may provide key insights into the device failure mechanisms as well as a means of improving device stability.

Future Work

This work marks the end of the present DOE research. Our future efforts to improve the stability of the metal-semiconductor interface will explore the effect of actually removing the steps by subsequent SiC epitaxy to produce atomically flat SiC surfaces. We expect this will also increase the thermal stability of the interface.

2. LIST OF PAPERS PUBLISHED, CONFERENCE PRESENTATIONS, STUDENTS SUPPORTED UNDER THIS GRANT

Publications

1. **Deposition and reaction of palladium on stepped 6H-SiC**, A.A. Woodworth, C.Y. Peng, C.D. Stinespring, K. Meehan (manuscript in preparation).
2. **Low temperature growth of SiC layers on Si (100) 1x1 surfaces using dimethyl and trimethyl silane**, C.Y. Peng, K. Ziemer, C.D. Stinespring, A.A. Woodworth (manuscript in preparation)

Invited Talks

1. **Palladium Thin Film Study on 6H-SiC**, Marshall University 2/20/04
2. **The Effects of 6H-SiC Surface Preparation on Palladium Silicide Formation**, The 2004 Spring Colloquium Series, Physics Department, Indiana University of Pennsylvania 3/19/04

Other Presentations

Surface and Thin Film Study of Initial Palladium Silicide Formation on 6H-SiC, Annual APS March Meeting (March 22-26, 2004) Palais des Congres de Montreal, Montreal, Quebec, Canada

Students Supported Under this Grant

C.Y. Peng – PhD student, Department of Chemical Engineering, West Virginia University
A.A. Woodworth, PhD student, Department of Physics, West Virginia University
C.D. Hudson – MS student, Department of Electrical and Computer Engineering, Virginia Tech
A. Bhatia - undergraduate student, Department of Electrical and Computer Engineering, Virginia Tech
C. Anderson – undergraduate student, Department of Electrical and Computer Engineering, Virginia Tech