ELECTROPHYSICAL PROPERTIES OF NANOFILMS

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ABSTRACT

Manganese silica thin films of different thicknesses were obtained in a magnetron device under high vacuum conditions. The surface resistance, surface concentration and Hall coefficients of nanosized manganese silicide films obtained by the ion-plasma method were measured on an HMS 5000 device. The Hall coefficient for a 102.3 nm thick film of manganese silicide grown on a silicon surface by the ion-plasma method is $2{,}8979 \cdot 10^{-5}$ sm^3/C.

Keywords: magnetron sputtering, nanofilms, electrical conductivity, Hall coefficient, manganese silicide, ion-plasma

The most popular methods of vacuum deposition of coatings on various types of surfaces are thermal evaporation, electron beam evaporation and various types of ion-plasma sputtering. In this case, just the methods of applying thin films, which are based on the sputtering of the material with ions of heavy gases.

These include the intensively developed recently ion-beam and magnetron deposition of thin-film structures. They have a number of advantages; the possibility of obtaining new materials, oxides, good adhesive and physico-chemical properties of diapers. Particularly important in the production of microelectronics elements require the application of multilayer coatings such as metal-dielectric, metal-dielectric-metal, metal-semiconductor-dielectric-metal, etc., which requires the use of a variety of vacuum-plasma equipment.

In the processes of ion-plasma deposition, the material deposited on the substrate is obtained by sputtering solid targets with ions with certain energies (mainly Ar^+ cones). The Department of TEF has a magnetron sputtering unit PDV-DESK-PRO [1]. Using these devices, technologies for obtaining nanolayers based on conductive diapers Cu, Al, Co, Mn, Ti, Ba, metal silicides, dielectric films SiO_2, Si_3N_4, as well as the compound Mn_4Si_7, TiO_2, Al_2O_3 and other films with a more complex composition.

The principle of operation of magnetron-type sputtering devices is based on the use of crossed electric and magnetic fields to form electron trajectories in plasma in the form of a closed spiral curve. The magnetic field, the lines of force of which are parallel to the surface of the sputtered magnetron target, keeps the electrons in the immediate vicinity of the target, in the so-called electron "trap" created by crossed electric and magnetic fields. Oscillations of electrons and their movement along helical trajectories increase the number of ionization collisions, as a result, the density of the plasma increases, the effect of which on the target ensures a high sputtering rate of the target material [2].

The use of dielectric materials, increased requirements for the quality of coatings, and an increase in the size of the substrate have led to a change in magnetron sputtering systems using high-frequency voltages.

A distinctive feature of magnetron sputtering systems is the high concentration of plasma in the immediate vicinity of the sputtered target due to the presence of a magnetron field. Therefore, in magnetron sputtering systems, it is possible to achieve large values of negative bias, hence, high-frequency sputtering efficiency [3].

The industry has mastered the production of a wide range of magnetron coating systems with target sizes of 40÷240 mm, input power level of 1÷10 kW, which operate using DC and RF voltage, both on DC and on electromagnets. Characteristic values, discharge voltages reach several kilovolts, discharge currents from 1 to 15 amperes, operating pressure range $10^{-3} \div 10^{-2}$ mmHg. The diagrams of ion-plasma devices for film deposition are shown below in Fig.1.

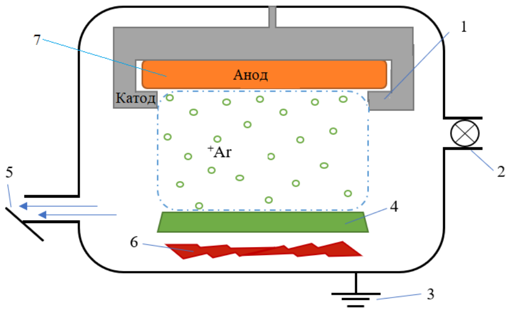

Fig.1. Scheme of magnetron sputtering. 1-cathode, 2-valve (Ar^+), 3-ground, 4-substrate (Si), 5-pump, 6-heater, 7-anode (target)

In magnetron sputtering systems, a glow discharge plasma of sufficiently high density is formed near the cathode due to the imposition of a magnetic field of shape definitions on an electric field directed from cathode 1 to anode 2 (Fig. 1) the shape of the dense plasma region determines the configuration of the sputtering zone, but the target is in the form of a groove. Magnetron sputtering can be used to sputter all conductive materials, except for magnetic ones [4]. When sputtering dielectric targets, the deposition of dielectric films is possible provided that a high-frequency voltage is applied to the magnetron or reactive sputtering is implemented.

The electrophysical properties of thin-layer manganese silicide films obtained by the ion-plasma method were measured on the HMS 5000 device. The HMS 5000 Hall effect detector is designed to measure thin films using a four-probe method. The systems cover the electrophysical properties of all semiconductors, including a variety of materials including Si, Mn_4Si_7, CoSi, $CoSi_2$ SiGe, SiC, GaN (n-type and p-type can be measured), metal layers, oxides and are designed to measure thin films [5]. Bulk concentration, sheet concentration, sheet resistance, resistivity, conductivity, mobility, average hall coefficient, A-C Hall coefficient, B-D Hall coefficient of thin films were measured using HMS 5000 device at room temperature.

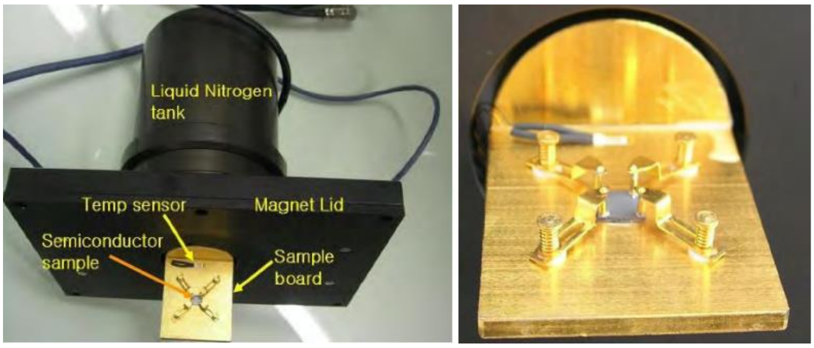

Fig. 2. Sample Mounting Fixture with upper cooling reservoir

10x10 dm square samples were taken for measurement. voltages and currents were measured for different points using four probes. AB=3665,45 mV, BC=3972,63 mV, CD=3491,29 mV, DA=3173,59 mV

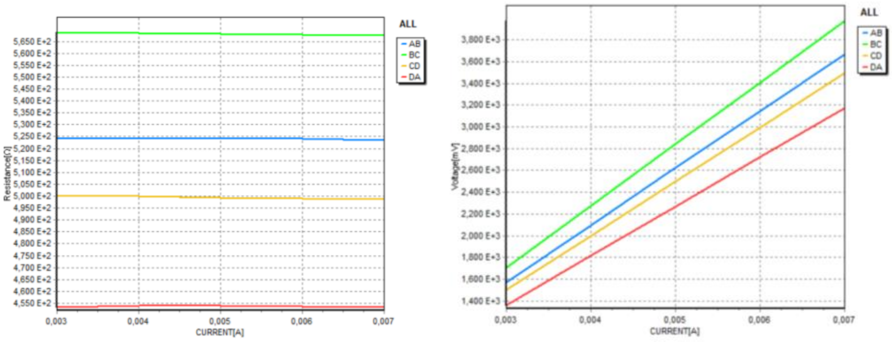

Fig. 3. Room temperature resistance of manganese silicide and VAX

Bulk Concentration =$2,1541*10^{23}$ sm^{-3}

Sheet Concentration =$2,2036*10^{18}$ sm^{-2}

Sheet Resistance=121,74 Ω/¤

Resistivity=$1,2453\cdot10^{-3}$ Ω

Conductivity=802,99 S/sm

Mobility=$2,327\cdot10^{-2}$ sm^2/Vs

Average Hall Coefficient=$2,8979\cdot10^{-5}$ sm^3/C

A-C Hall Coefficient=$2,9439\cdot10^{-5}$ sm^3/C

B-D Hall Coefficient=$2,8519\cdot10^{-5}$ sm^3/C

Ratio vertical/horizontal =0,97469

Obtaining nanofilms with good electrical conductivity and increasing their electrical conductivity is relevant for microcircuits used in modern electronic devices.

The electrophysical properties of thin-layer films obtained by the ion-plasma method using magnetron sputtering were studied. In the measurement results, many parameters were measured at room temperature. The Hall coefficient for a 102.3 nm thick film of manganese silicide grown on a silicon surface by the ion-plasma method is $2{,}8979\cdot10^{-5}$ sm^3/C. In the following works, the Hall coefficient of the Mn_4Si_7 film of different thicknesses at different temperatures is determined.

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