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Artur KURPIEWSKI, Marta KAMIŃSKA
INSTITUTE OF EXPERIMENTAL PHYSICS, WARSAW UNIVERSITY
Hoża 69, 00-681 Warszawa

Maria PALCZEWSKA
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Wólczyńska 133, 01-919 Warszawa

Ericke R. WEBER
UNIVERSITY OF CALIFORNIA
Berkeley, CA 94720, USA

ANTISITE ARSENIC RELATED DEFECTS IN LOW TEMPERATURE GaAs

The growth of molecular beam epitaxy (MBE) GaAs at low (200-250°C) substrate temperatures (often referred to as LT GaAs) was initialized in 1987 at Lincoln Laboratory. It quickly occurred that LT GaAs layers used as buffer layers reduced backgating or sidegating in semiconducting devices and circuits. On the other hand, the unusual structural, electrical and optical properties of LT GaAs layers made them an interesting subject of research studies. Among the most striking features of LT GaAs layers were the approximately one atomic percent excess of As, lattice expansion of the order of 0.1% in comparison with bulk GaAs and extremely high concentration of antisite arsenic related defects of the order of 10^{20} cm^{-3} relative to 10^{16} cm^{-3} concentration of EL2 defect in bulk GaAs. It was also found that some of antisite arsenic defects in LT GaAs showed metastability under illumination at helium temperatures. However, no systematic studies of this property as well as no comparison with well known metastability of EL2 defect have been done.
In this paper EPR and optical absorption studies of LT GaAs grown at 190, 200, 220 and 260°C substrate temperatures are presented. From the characteristic EPR quadruplet signal and near-infrared absorption band, both related to antisite arsenic, a total concentration of this defect in the layers grown at different temperatures was determined. It was found that Fermi level position is controlled by the antisite arsenic defect. The extensive studies of the metastable property of antisite arsenic defect in LT GaAs layers were performed at helium temperatures using monochromatic light illumination. Partial quenching of the near-infrared absorption band was observed. The excitation spectrum of the absorption quenching showed two peaks: higher at about λ=900 nm and lower at about λ=1000 nm, whereas the well known analogous spectrum for EL2 defect had only one maximum at about λ=1000 nm. The thermal recovery of antisite arsenic defects in LT GaAs was the same as EL2 thermal recovery in semi-

-insulating GaAs and took place at about 130K. However, it was found that optical recovery process is also very efficient in LT GaAs at helium temperature. Light illumination of about 0.9 eV transferred significant part (~80%) of the metastable defects to their normal configuration.
The optical recovery of EL2 is negligible at helium temperature. Basing on the analysis of the experimental data it is proposed that three kinds of antisite arsenic defects are present in LT layers, one of them similar to EL2 defect in bulk GaAs.
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Robert DWILINSKI, Maria KAMINSKA
INSTITUTE OF EXPERIMENTAL PHYSICS, WARSAW UNIVERSITY
Hoża 69, 00-681 Warszawa

Maria PALCZEWSKA
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Wólczyńska 133, 01-919 Warszawa

Tomasz SLUPIŃSKI
LABORATORY OF CRYSTAL GROWTH
Przyokopowa 28, 01-208 Warszawa

OPTICAL ABSORPTION AND EPR STUDIES OF DEEP ACCEPTOR DEFECTS IN BULK GaAs

The knowledge about impurities and defects important for compensation mechanism in bulk semi-insulating (SI) GaAs is far from being satisfactory. It is commonly believed that sulfur and silicon are the major nonintentional shallow donor species, carbon often plays an important role as a nonintentional acceptor and EL2 defect with its midgap position controls the Fermi level. However, it often occurs that in order to understand SI property of GaAs, extra acceptors are needed. Different candidates has been proposed, among them antisite gallium, antisite boron and so called FR1 and FR2 defects. Very little is known about these acceptors. Especially, FR1 and FR2 defects are recognized only from their EPR spectra.

In this paper the systematic EPR and optical absorption studies performed on bulk GaAs containing FR1 and FR2 defects are presented. The metastable changes of EPR signal and absorption spectrum after illumination at helium temperature were observed. Thermal recovery of EPR signal as well as absorption spectrum after previous illumination were traced up to room temperature. In the case of the absorption spectrum recovery the measurement was made for different wavelengths what allowed to get rid of well known EL2-induced modification of the observed spectra. It was then possible to correlate the observed changes of absorption spectrum after illumination with the EPR signal changes due to FR1 and FR2 defects. As a result of these studies unknown absorption spectra of defects in GaAs were found and their relation to FR1 and FR2 defects is given.

Informacja przygotowana dla kwartalnika "Materiały Elektroniczne".

Przemysław BYSZEWSKI
INSTITUTE OF PHYSICS POLISH ACADEMY OF SCIENCES
al. Lotników 32/46, 02-668 Warszawa

Anna PAJĄCZKOWSKA, Jerzy SASS, Krystyna MAZUR
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Wólczyńska 133, 01-919 Warszawa

CRYSTALLIZATION OF $CaNdAlO_4$ (CNA) AND $SrLaAlO_4$ COMPOUNDS

Crystallization of $CaNdAlO_4$ (CNA) and $SrLaAlO_4$ (SLA) by Czochralski method was investigated. Composition of melts and crystallographic aspects of crystal growth was considered. The experiments showed that best crystals are obtained if they are grown in the nonstoichiometric melt and crystallization occurs on (101) planes. Large single crystals of both materials were obtained.

Pełny tekst wystąpienia opublikowany będzie w materiałach konferencyjnych.

CSI — IUPAC XXVII Colloguium Spectroscopicum Internationale Grieg Hall Bergen, Norway 9-14.06.1991

Krzysztof KALINOWSKI, Agata KARAŚ, Danuta DĄBROWSKA
INSTYTUT TECHNOLOGII MATERIAŁÓW ELEKTRONICZNYCH
Wólczyńska 133, 01-919 Warszawa

ZASTOSOWANIE SPEKTROMETRII MAS ZE WZBUDZENIEM ISKROWYM W ANALIZIE MATERIAŁÓW STOSOWANYCH W MIKROELEKTRONICE

Spektrometria mas ze wzbudzeniem iskrowym (SSMS) i detektorem fotograficznym jest ciągle uważana za jedną z bardziej czułych wielopierwiastkowych metod śladowej analizy objętościowej, ciał stałych, proszków i koncentratów osadzanych na kolektorach wysokiej czystości.
Zaprezentowano pięć przykładów zastosowań SSMS w analizie materiałów używanych w technologii materiałów elektronicznych:

- ilościowa (kalibrowana na międzynarodowe wzorce analityczne) śladowa analiza metali wysokiej czystości (In, Zn, Cu, Al),
- quazi-ilościowa objętościowa analiza śladowa GaAs,
- oznaczanie śladowych nieorganicznych zanieczyszczeń w związkach metaloorganicznych dla MOCVD,
- oznaczanie B i P w warstwach szkliw SiO-PO-BO na krzemie półprzewodnikowym,
- ilościowa analiza śladowa materiałów tlenkowych CuO, Y_2O_3 i innych.

We wszystkich prezentowanych przykładach metod zostały przedyskutowane koncepcje badania precyzji i dokładność wyników analizy śladowej. W wybranych przykładach przedstawiono porównanie możliwości analitycznych SSMS z wynikami uzyskanymi z użyciem innych metod analitycznych.

Informacja o wystąpieniu przygotowana dla kwartalnika "Materiały Elektroniczne".

Krystyna MAZUR, Jerzy SASS
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Konstruktorska 6, 02-637 Warszawa

THE INVESTIGATION OF $LaGaO_3$ SINGLE CRYSTAL STRUCTURE

Lanthanum Gallate is a promising new substrate material for epitaxial high temperature superconducting thin films. The 1.6% lattice misfit enables the growth of monocrystalline $YBa_2Cu_3O_{7-x}$ films with sufficiently perfect structure up to the thickness about 0.6 μm. The possible matches to the $YBa_2Cu_3O_{7-x}$ unite cell are better than with the others like for example $SrTiO_3$. The structural defects in the substrate may imply the limitation of homogeneous effective area of the monocrystalline epitaxial layer.
In our paper the structural defects in the substrate $LaGaO_3$ were investigated by means of X-ray diffraction topography. The crystal plates were cut perpendicullar to the growth axies [011]. It was established occuring the longitudinal volume defects.
It was estated that these volume defects are crystalline as well, but with different interplanar spacing "d". Basides it was shown that in the defect region the planes (044) are continued by the planes (404) with the angle inclination of a few minutes. The separating plane is the $(1\bar{1}\ 2)$.

Pełny tekst wystąpienia opublikowany będzie w materiałach z konferencji.

Acoustoelectronics '91. The fifth Conference with International Participation
Varna 10-13.09.1991

Władysław HOFMAN
INSTYTUT TECHNOLOGII MATERIAŁÓW ELEKTRONICZNYCH
Wólczyńska 133, 01-919 Warszawa

WPŁYW WARUNKÓW BRZEGOWYCH NA POLE TEMPERATUR AUTOKLAWU DO MONOKRYSTALIZACJI KWARCU

Wykazano możliwość uzyskania w 8.5-litrowym autoklawie wysokociśnieniowym dwóch różnych stanów cieplnych o zgodnych parametrach temperaturowo-ciśnieniowych rejestrowanych każdorazowo w procesie hydrotermalnym. Oba analizowane stany były termicznie ustalone a "ciągłe" przejście od pierwszego z nich do drugiego zrealizowano zwiększając intensywność chłodzenia obszaru międzysektorowego, dobierając stosownie wzrost mocy sekcji grzewczych obu komór oraz wypuszczając nadmiar roztworu z autoklawu. Wprowadzonym zmianom towarzyszyły istotne zmiany rozkładów temperatury na pancerzu zbiornika. Eksperymentalne ocenienie tych rozkładów oraz zaadaptowanie prostego modelu jednooczkowej symetrycznej konwekcji cieczy dla każdej z komór autoklawu pozwoliło na numeryczne wyznaczenie "pól" temperatur obu badanych stanów cieplnych "zbiornika" Wyniki obliczeń pokazały, że zastosowanie intensywnego chłodzenia strefy międzysektorowej prowadzi do powiększenia radialnych gradientów temperatury w objętościach komór zbiornika a w efekcie do zintensyfikowania ruchu strumieni konwekcyjnych cieczy. Można podejrzewać, że w przypadku procesu hodowli kwarcu, kontrolowanego transportem masy na skutek niedostatecznie intensywnej konwekcji (duże autoklawy, standardowe warunki wzrostu), lokalne zmiany rozkładów temperatury na powierzchni zbiornika mogą zauważalnie wpływać na zmiany szybkości wzrostu brył. W normalnej praktyce produkcyjnej obecność niestabilnych wahań temperatury jest wysoce prawdopodobna. Zmiany te związane są z nierównomierną pracą grzałek, stopniowym zużyciem materiałów termoizolacyjnych oraz fluktuacjami temperatury powietrza w otoczeniu pieca.

Pełny tekst wystąpienia opublikowany będzie w materiałach ww. konferencji.

2-nd European Ceramics Society Conference
Augsburg, FRg 11-14.09.1991

Henryk TOMASZEWSKI
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Konstruktorska 6, 02-673 Warszawa

INFLUENCE OF MICROSTRUCTURE ON THERMOMECHANICAL PROPERTIES OF ALUMINA CERAMICS

This paper demonstrated, that microstructure of alumina ceramics strongly effects on its mechanical properties. A special range of Al_2O_3 grain size (90-130 μm) was found where increase of resistance to fracture and grinding was observed.
This region corresponds to maximum density of microcracks with length close to l_m value from minimum curve of Hasselman.
The interaction of crack front with microcracks existing in alumina ceramics is regarded as possible mechanism of observed toughening.
In case of ceramics with grain size above 300 μm, increase of microcrack length to above 500 μm and decrease of microcrack density was observed. Macrocrack growth takes place here by linking of microcracks, reducing the resistance to fracture of alumina ceramics.

Pełny tekst wystąpienia opublikowany będzie w materiałach konferencyjnych.

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Frankfurt/M, 03-07.09.1991

Michał KOPCEWICZ, Jacek JAGIELSKI, Grzegorz GAWLIK
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Wólczyńska 133, 01-919 Warszawa

Andrzej TUROS
SOLTAN INSTITUTE FOR NUCLEAR STUDIES
Hoża 69, 00-681 Warszawa

PHASE DIAGRAM OF IMPLANTED FeN SYSTEM

A systematic study of nitride phases formation in iron implanted with nitrogen was performed using conversion electron Mössbauer spectroscopy (CEMS).
The samples of α -iron (armco) were implanted at room temperature with 100 keV N_2^+ at doses ranging from $5x10^{16}$ to $6x10^{17}$ N at./cm^2. After implantation each sample was isothermally annealed in vacuum at temperatures from 150°C to 500°C in 50°C steps, for 1 h. The CEMS measurements allowed to identify the iron nitride phases formed by implantation. The study of phase evolution due to annealing allowed us to derive a new phase diagram for implanted FeN system.

Pełny tekst wystąpienia opublikowany będzie w materiałach z konferencji: Nuclear Instruments and Physics Research.

ISHM-XV th Conference of the ISHM, Poland Chapter, Kraków, 16-18.09.1991

Małgorzata JAKUBOWSKA, Elżbieta ZWIERKOWSKA,
Selim ACHMATOWICZ
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Wólczyńska 133, 01-919 Warszawa

THE NEW COPPER PASTE FIRED AT 650°C IN NITROGEN

The new copper paste fired in nitrogen atmosphere with low oxygen content, at 650°C is presented in this paper. The aim to elaborate such a paste was to combine the traditional resistive pastes fired in air (850°C) with conductive pastes based on non-noble metals.
The study on the paste components, the paste composition, the firing profile and the compatibility with ruthenium based pastes (eg. resistive serie R-340) is presented. The comparison of resistors with copper and palladium silver terminations is given.

Pełny tekst wystąpienia opublikowany będzie w materiałach z konferencji.

ICAME 91-International Conference on the Applications of the Mössbauer Effect
Nanjing, Chiny, 16-20.09.1991

Michał KOPCEWICZ
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Wólczyńska 133, 01-919 Warszawa

FREQUENCY DEPENDENCE OF THE RADIO FREQUENCY COLLAPSE EFFECT

Various models of radio frequency (rf) collapse observed in the Mössbauer spectra of some soft ferromagnetic materials exposed to the rf fields predict a different dependence of this effect on the frequency of the rf field [1, 2]. The model proposed by Pfeiffer [1] shows that full collapse of the magnetic hyperfine splitting can occur only for the rf field frequency higher than the Larmor precession frequency ω_L. A recently presented model [3] suggests another characteristic frequency, not related to the Larmor frequency. In order to verify experimentally the model predictions a systematic study of the frequency dependence of the rf collapse effect was performed. The experiment was performed for two soft ferromagnetic materials: crystalline FeNi alloy (Permalloy) and amorphous $Fe_{45}Ni_{30}Si_{10}B_{15}$ alloy, subjected to rf fields with frequencies varying from 12 MHz, i.e. the frequency much lower than ω_L, to 64 MHz, i.e. the frequency much higher than ω_L. The rf field intensity used was about 10 and 20 Oe, and thus was considerably higher than the anisotropy fields in the materials studied.
The results obtained show that the rf collapse effect does not occur below ω_L and appears gradually in both materials as the frequency of the rf field exceeds ω_L. This behaviour is especially pronounced for the amorphous alloy. Since both alloys are magnetostrictive the rf collapse is accompanied by the rf sideband effect. The rf sideband effect, which is particularly strong at low frequencies, decreases with increasing rf field frequency, in agreement with the magnetostriction model of the rf sideband effect.

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Pełny tekst wystąpienia opublikowany będzie w materiałach z konferencji Hyperfine Interactions-ICAME 91.

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Michał KOPCEWICZ, Jacek JAGIELSKI
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Wólczyńska 133, 01-919 Warszawa

Andrzej TUROS
SOLTAN INSTITUTE FOR NUCLEAR STUDIES
Hoża 69, 00-681 Warszawa

MÖSSBAUER STUDY OF THE PHASE FORMATION IN NITROGEN IMPLANTED IRON

Nitrogen implantation into metallic iron and steels is very important in view of the technological application of this process for the surface improvement. Despite numerous studies [1-3] the basic phenomena related to the implantation process are not yet fully understood. We performed a detailed and systematic study of metallic iron implanted with nitrogen using conversion electron Mössbauer spectroscopy (CEMS). The samples of pure metallic iron (armco) were implanted at room temperature with 100 keV N_2^+ ions whose mean range in the iron target was about 550 A. The implanted dose varied from 5×10^{16} to 6×10^{17} at/cm^2. After implantation each sample was isothermally annealed in vacuum at temperatures from 200°C to 550°C in 50°C steps, being kept 1 h at each temperature. The formation of the nitride phases in as implanted samples and their evolution due to annealing was analyzed by CEMS. The CEMS measurements allowed to identify the FeN phases formed by implantation. At low doses (up to 1×10^{17} at/cm^2) apart from α -Fe the martensite α' and/or $Fe_{16}N_2$ α'' phases appear. For intermediate doses (1×10^{17} - 2.5×10^{17} at/cm^2) Fe_4N and Fe_3N are formed additionally. For doses higher than 3×10^{17} at/cm^2 the spectra consist of the characteristic magnetic hf pattern of α -Fe and the quadrupole doublet of ε -Fe_2N. In the course of annealing ε -Fe_2N decomposes to ε -Fe_3N and γ' -Fe_4N and finally disappears at about 400°C. At 500°C only the Zeeman sextet of α -Fe remains in the spectra. The evolution of all nitride phases was followed qualitatively. These measurements allowed us to derive a new phase diagram for the FeN system, which differs considerably from the earlier findings [4].

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Michał KOPCEWICZ, Jacek JAGIELSKI
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Wólczyńska 133, 01-919 Warszawa

Andrzej TUROS
SOLTAN INSTITUTE FOR NUCLEAR STUDIES
Hoża 69, 00-681 Warszawa

ON THE ROLE OF ALLOYING ELEMENTS IN NITROGEN IMPLANTED IRON

Nitrogen implantation is a commonly used technique for surface modification of technological materials, e.g. steels. However, in order to understand better the influence of various steel components on the formation and stability of nitrogen containing phases formed due to implantation we performed a detailed study of model systems - pure metallic iron implanted with Cr^+ or Al^+ and then post implanted with N_2^+. The energies of Cr^+ and N_2^+, and Al^+ and N_2^+ ions were such that the ranges of these ions in the iron target were similar and equaled to about 600 A.
Metallic iron samples were implanted with 150 keV Cr^+ ions at doses of $3x10^{16}$ and $1.5x10^{17}$ at/cm^2, and then with $1x10^{17}$ and $4x10^{17}$ nitrogen ions/cm^2 or with 95 keV Al^+ and then with nitrogen (dose $3x10^{16}$ and $1.5x10^{17}$ N at./cm^2). Such samples were then annealed in vacuum in the temperature range from 200°C to 550°C in 50°C steps, for 1 h at each step. The formation and evolution of various nitrogen containing phases was analyzed by CEMS.
The results were compared with the detailed study of N implanted α -Fe [1].
The results obtained show that the introduction of alloying elements such as Cr and Al greatly increases the thermal stability of nitride phases formed due to ion implantation. Our study has a clear advantage over earlier investigations [2] in which commercial steels were implanted, because we could follow the role of an individual alloying component of well defined concentration in the material modifiaction due to nitrogen implantation.

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ICAME 91-International Conference on the Applications of the Mössbauer Effect
Nanjing, Chiny, 16-20.09.1991

Michał KOPCEWICZ
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY
Wólczyńska 133, 01-919 Warszawa

Barbara KOPCEWICZ
INSTITUTE OF GEOPHYSICS, POLISH ACADEMY OF SCIENCES
Księcia Janusza 64, 01-452 Warszawa

SEASONAL VARIATIONS OF IRON CONCENTRATION IN ATMOSPHERIC AEROSOLS

As it is well known, aerosols play a significant role in atmospheric physics. Iron is one of the most important elements appearing in the form of aerosols. The main sources of iron containing particulate matter include soil dust, particulate emission from industry, exhaust from car engines, oil and coal-fired power plants, and natural sources, such as extraterrestrial particles and meteor showers. Studies of the size, mass distribution and concentration of iron-containing particles are important for the investigations of condensation processes and atmospheric precipitation, which, in turn, are very important for cloud physics and health sciences. The importance of iron in condensation processes is enhanced by interactions between iron and sulfur dioxide in the atmosphere. Iron oxide can chemisorb sulfur dioxide, converting it to sulfate at the gas-solid interface. Interaction of a layer of sulfate material on an otherwise relatively insoluble particle could enhance its cloud nucleation capacity [1] and the particle can grow much easier even at humidities of less than 100%. It was shown [2] that the Mössbauer effect can be successfully used to study the properties and concentration of iron in the atmospheric air. As a continuation of our earlier studies [3] the Mössbauer technique was applied to study the seasonal variations of iron concentration in atmospheric air. The results obtained are discussed with respect to meteorological conditions.

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Pełny tekst wystąpienia ukaże się w materiałach z konferencji Hyperfine Interactions - ICAME 91.