

MATEMAATIKA-LOODUSTEADUSKOND
FÜÜSIKAINSTITUUT
TEADUS- JA ARENDUSTEGEVUSE AASTAARUANNE 2012

1. Instituudi struktuur

Füüsikainstituut, Department of Physics
Instituudi direktor Pavel Suurvarik

- Rakendusfüüsika õppetool, Chair of Applied Physics, Jüri Krustok
- Teoreetilise füüsika õppetool, Chair of Theoretical Physics, Rein-Karl Loide

2. Instituudi teadus- ja arendustegevuse (edaspidi T&A) iseloomustus

(NB! punktid 2.1- 2.6 täidab struktuuriüksus)

2.1 struktuuriüksuse koosseisu kuuluvate uurimisgruppide

2.1.1 teadustöö kirjeldus *(inglise keeles)*;

2.1.2 aruandeaastal saadud tähtsamad teadustulemused *(inglise keeles)*.

Chair of Applied Physics

Research topics in the Chair of Applied Physics are mainly related to semiconductor physics. Most studies involve optical and electrical characterization of absorber materials for solar cells. Low temperature photoluminescence spectroscopy, Raman spectroscopy, capacitance spectroscopy and modulation spectroscopy are the main experimental methods. Studied materials include $\text{Cu}_2\text{ZnSn}(\text{Se}_x\text{S}_{1-x})_4$ and CdTe. In addition some ferromagnetic materials were studied in co-operation with KBFI.

Main results in 2012 involve a new recombination model in $\text{Cu}_2\text{ZnSnS}_4$. Two PL bands at 1.27 eV and 1.35 eV at $T = 10$ K were detected. Similar behaviour with temperature and excitation power was found for both PL bands and attributed to the band-to-impurity recombination. Interestingly, the thermal activation energies determined from the temperature dependence of the PL bands coincide. With the support of the Raman results, we proposed that the observed PL bands arise from the band-to-impurity-recombination process involving the same deep acceptor defect with ionization energy of around 280meV but different $\text{Cu}_2\text{ZnSnS}_4$ phase with different bandgap energy. A low temperature electroreflectance spectroscopy was implemented to study CdTe solar cells. In addition admittance spectroscopy studies were performed in $\text{Cu}_2\text{ZnSnSe}_4$ solar cells.

Chair of Theoretical Physics

Solid state theory. The substitutional impurities such as zinc, copper and zirconium ions incorporated into the magnesium sublattice of MgB were investigated by abinitio modeling. MD simulations of recoil processes, following the scattering of X-rays or neutrons are performed. It is found that the substitution in MgB2 not only always affects the existing overall picture of the electronic states involved in the chemical bonding, but also that the resulting charge rearrangement around the host cation position is exhibited quite differently among substitutional ions considered.

Quantum field theory. The studies of relativistic wave equations for arbitrary spin (superspin) fields and superfields, algebras and superalgebras are continued. Massless limit of massive half-odd spin particles and massive supergravity is investigated. The possible content of masses of a given massless equation in the massive case is given. It appears that these additional states are playing important role when interactions with other fields are involved. The results of studies are reported on the international conference Algebra Geometry Information, Tallinn 10 - 13 July 2012.

Astrophysics. Photogrammetric mapping of the Apollo 11 landing site was completed and mapping of Apollo 12 was started. A camera stations map including more than 230 individual camera stations was prepared, most camera stations in the proximity of the Lunar Module and at the Apollo Lunar Surface Experiment Package were positioned, as well as some cameras within the Surveyor crater. Locations of artifacts were determined and were found to be in a perfect agreement with orbital images made by Lunar Reconnaissance Orbiter. This is the first camera stations map for Apollo 12 ever made. The work continues and the results will be prepared for publication.

2.2 Uurimisgrupi kuni 5 olulisemat publikatsiooni läinud aastal.

Chair of Applied Physics

- M. Chandra Dimri, H. Khanduri, H. Kooskora, J. Subbi, I. Heinmaa, A. Mere, J. Krustok, and R. Stern. Ferromagnetism in rare earth doped cerium oxide bulk samples, *Phys. Stat. Sol. A*, 209 (2012) 353-358.
- M. Grossberg, J. Krustok, J. Raudoja, and T. Raadik, The role of structural properties on deep defect states in $\text{Cu}_2\text{ZnSnS}_4$ studied by photoluminescence spectroscopy, *Appl. Phys. Lett.* **101**, 102102 (2012).
- M. Chandra Dimri, H. Khanduri, H. Kooskora, M. Kodu, R. Jaaniso, I. Heinmaa, A. Mere, J. Krustok, R. Stern. Room-temperature ferromagnetism in Ca and Mg stabilized cubic zirconia bulk samples and thin films prepared by pulsed laser deposition, *J. Phys. D: Appl. Phys.* **45** (2012) 475003.
- H. Khanduri, M. Chandra Dimri, H. Kooskora, I. Heinmaa, G. Viola, H. Ning, M. J. Reece, J. Krustok, and R. Stern. Structural, dielectric, magnetic, and nuclear magnetic resonance studies of multiferroic Y-type hexaferrites, *J. Appl. Phys.* **112**, 073903 (2012).
- T. Raadik, J. Krustok, R. Josepson, J. Hiie, T. Potlog, N. Spalatu. Temperature dependent electroreflectance study of CdTe solar cells. *Thin Solid Films* (in press).

Chair of Theoretical Physics

- Pishtshev, A.; Klopov, M. (2012). Assessing structural bonding aspects of multiband superconductors through impurity-induced local lattice distortions: a case study on MgB_2 . *International Journal of Quantum Chemistry*, x[ilmumas]

2.3 Loetelu struktuuriüksuse töötajate rahvusvahelistest tunnustustest.

2.4 Loetelu struktuuriüksuse töötajatest, kes on välisakadeemiate või muude oluliste T&A-ga seotud välisorganisatsioonide liikmed.

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2.5 Aruandeaasta tähtsamad T&A finantseerimise allikad.

Nende loetelu on antud punktis 2.7.

2.6 Soovi korral lisada aruandeaastal saadud T&A-ga seotud tunnustusi (va punktis 2.3 toodud tunnustused), ülevaate teaduskorralduslikust tegevusest, teadlasmobiilsusest ning anda hinnang oma teadustulemustele.

2.7 Instituudi teadus- ja arendustegevuse teemade ja projektide nimetused (*Eesti Teadusinfosüsteemi, edaspidi ETIS, andmetel*)

- Haridus- ja Teadusministeerium

- sihtfinantseeritavad teemad:

- baasfinantseerimise toetusfondist rahastatud projektid (sh TTÜ tippkeskused):

BYF, Päikesepatareide ja nende materjalide elektriliste omaduste mõõtesüsteemi arendamine, Raavo Josepson, 2012- 2013.

- riiklikud programmid:

- Teiste ministeeriumide poolt rahastatavad riiklikud programmid:

- Uurija-professori rahastamine:

- SA Eesti Teadusfond/Eesti Teadusagentuur

- grandid:

- ühisgrandid välisriigiga:

- järel doktorite grandid (SA ETF ja Mobilitas):

- tippteadlase grandid (Mobilitas):

- Ettevõtluse Arendamise SA

- eeluuringud:

- arendustoetused:

- SA Archimedesega sõlmitud lepingud

- infrastruktuur (nn „mini-infra“, „asutuse infra“):

- Eesti tippkeskused:

- riiklikud programmid:

AR12118, materjalitehnoloogia, Efficient plasmonic absorbers for solar cells, Alvar Kurrel (1.07.2012-31.12.2014)

- muud T&A lepingud:

- SA Keskkonnainvesteeringute Keskusega sõlmitud lepingud:

KIK11064, Valgusreostuse pikaajaliste muutuste uurimine Tallinnas ja valgusreostuse hetkeseisu määramine Eestis, Mars Mario (27.06.2011 - 31.12.2012)

- Siseriiklikud lepingud:
- EL Raamprogrammi projektid:
- Välisriiklikud lepingud:

2.8 Struktuuriüksuse töötajate poolt avaldatud eelretsenseeritavad teaduspublikatsioonid (*ETIS klassifikaatori alusel 1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1 ja 5.1*).

1.1

Pishtshev, A.; Klopov, M. (2012). Assessing structural bonding aspects of multiband superconductors through impurity-induced local lattice distortions: a case study on MgB₂. *International Journal of Quantum Chemistry*, x [ilmumas]

Dimri, Mukesh Chandra; Khanduri, Himani; Kooskora, Helgi; Subbi, Juhan ; Heinmaa, Ivo; Mere, Arvo; Krustok, J; Stern, Raivo (2012). Ferromagnetism in rare earth doped cerium oxide bulk samples. *physica status solidi (a)*, 353 - 358.

Surzhenkov, Andrei; Adoberg, Eron; Põdra, Priit; Sergejev, Fjodor; Mere, Arvo; Viljus, Mart; Mikli, Valdek; Antonov, Maksim; Kulu, Priit (2012). Impact and Sliding Wear Properties of Single Layer, Multilayer and Nanocomposite Physical Vapour Deposited (PVD) Coatings on the Plasma Nitrided Low-Alloy 42CrMo₄ Steel. *Key Engineering Materials*, xxxx - xxxx. [ilmumas]

Dimri, Mukesh Chandra; Khanduri, Himani; Kooskora, Helgi; Kodu, Margus; Jaaniso, Raivo; Heinmaa, Ivo; Mere, Arvo; Krustok, Juri; Stern, Raivo (2012). Room-temperature ferromagnetism in Ca and Mg stabilized cubic zirconia bulk samples and thin films prepared by pulsed laser deposition. *Journal of Physics D: Applied Physics*, 45, 475003 - 475009.

Khanduri, H.; Chandra Dimri, M.; Kooskora, H.; Heinmaa, I.; Viola, G.; Ning, H.; Reece, M. J.; Krustok, J.; Stern, R. (2012). Structural, dielectric, magnetic, and nuclear magnetic resonance studies of multiferroic Y-type hexaferrites. *Journal of Applied Physics*, 112, 073903

1.2

1.3

Gavrilov, A. (2012). Generator impulsov. *Radio*, 7, 51 - 52.

2.1

2.2

3.1

3.2

3.3

4.1

5.1

2.9 Struktuuriüksuses kaitstud doktoriväitekirjade loetelu (*NB! struktuuriüksus lisab struktuuriüksuse töötaja juhendamisel mujal kaitstud doktoriväitekirjade loetelu*)

2.10 Struktuuriüksuses järel doktorina T&A-s osalenud isikute loetelu (*ETIS-e kaudu esitatud taotluste alusel*)

2.11 Struktuuriüksuses loodud tööstusomandi loetelu

3. Struktuuriüksuse infrastruktuuri uuendamise loetelu (*summa eurodes*)

PV007326, Heeliumkrüostaat II-119, 24.02.2012 (15 948,40)

PV007466, IV-meeter sn:4004350 II-119, 10.10.2012 (2 900,00)