

COVER PAGE

Sent: 26/02/2018 16:49 **Project Code:** 18T-1C141

1. Project Title: Radiation resistance of silicon based thermal barrier coating materials
2. Field of Science: Natural Sciences - Physics and Astronomy
3. Nature of Research: Applied
4. Type of Research: Experimental
5. Principal Investigator: Aleksanyan Eduard Mnacakan
6. Organization: Ministry of Education and Science of RA - "A.Alikhanyan National Laboratory (Yerevan Physics Institute)" Foundation of MES RA
7. Duration: 24 months
8. Research group structure: Principal Investigator, Consultant, 3 Members
9. Total Requested Budget: 13200.0 thousand drams
- Total Individual Financial Support: 9600.0 thousand drams
- Overhead: 190.0 thousand drams

Project Annotation

Nowadays cosmic radiation (CR) is one of the main hazards of spacecraft and the safety of astronauts. Minimizing the changes caused by the CR is a crucial challenge for contemporary science. Currently plates obtained from silicate solution based powders such as zinc, zirconium, sodium, silicates, are well-known as thermal barrier coatings. However, during long-term orbit flights, even such materials lose their initial properties, resulting in a large number of defects and absorption centers, therefore reduced reflection in wide wavelength range and, consequently, increases of absorption. For this reason, the study of the physico-chemical properties and influence of irradiation on such materials, is a crucial problem and it will allow to select or obtain new types of materials with most improved parameters. The aim of this study is to investigate the radiation resistance of thermal barrier coatings based on silicate compounds obtained by new method by using high-energy electron, proton beam and photon radiation. Structural changes in the materials under the influence of radiation will be studied by means of spectral analysis.

Keywords: Thermal barrier coating; radiation; defect; luminescence; electron beam

INFORMATION ON THE PROJECT PRINCIPAL INVESTIGATOR

Aleksanyan Eduard Mnacakan	
Date of Birth:	1983 July 28
Selected Education:	Yerevan Physics Institute, Applied Physics Department, PhD Program, 2006-2009, Candidate of Science
Degree:	Candidate of Physico-Mathematical Sciences
Title of the last thesis, Specialty Code, year and place of defense:	Excitation of radiation defects and doped ions in wide gap laser single crystals, U.04.07 - Կոնդենսացված վիճակի ֆիզիկա, 2009, Institute of Applied Problems of Physics, NAS of RA, 021
Affiliation and Position:	Ministry of Education and Science of RA - "A.Alikhanyan National Laboratory (Yerevan Physics Institute)" Foundation of MES RA, Senior Researcher
E-mail:	aeduard@mail.yerphi.am
Number of publications registered in the System:	20
Total number of monographs and publications in Compendiums registered in the System:	0
Number of meeting's materials in proceedings including abstracts registered in the System:	13
Number of Grants from RA MES SCS and other sources registered in the System:	0

Publications in line with the current project objectives (up to 10) (2012-2017)

Articles in scientific journals

1. Eduard Aleksanyan, Marco Kirm, Eduard Feldbach, Kaupo Kukli, Sven Lange, Ilmo Sildos, Aile Tamm // Luminescence properties of Er³⁺ doped zirconia thin films and ZrO₂/Er₂O₃ nanolaminates grown by atomic layer deposition / Optical Materials, 2017, 74, 27-33.
2. I. Romet, E.Aleksanyan, M.G.Brik, G.Corradi, A.Kotlov, V.Nagirnyi, K.Polgár // Journal of Luminescence, 2016, 177, 9-16.
3. E. Aleksanyan, M. Kirm, E. Feldbach, V. Harutyunyan // Radiation Measurements, 2016, 90, 84-89.
4. N. Mironova-Ulmane, V. Skvortsova, A. Pavlenko, E. Feldbach, A. Lushchik, Ch. Lushchik, V. Churmanov, D. Ivanov, V. Ivanov, E. Aleksanyan // Radiation Measurements, 2016, 90, 122-126.
5. V.S. Levushkina, D.A. Spassky, E.M. Aleksanyan, M.G. Brik, M.S. Tretyakova, B.I. Zadneprovski, A.N. Belsky // Bandgap engineering of the LuxY1-xPO₄ mixed crystals / Journal of Luminescence, 2015, 171, 33-39.
6. D.A. Spassky, V. Nagirnyi, A.E. Savon, I.A. Kamenskikh, O.P. Barinova, S.V. Kirsanova, V.D. Grigorieva, N.V. Ivannikova, V.N. Shlegel, E. Aleksanyan, A.P. Yelissev, A. Belsky // Low temperature luminescence and charge carrier trapping in a cryogenic scintillator Li₂MoO₄ / Journal of Luminescence, 2015, 166, 195-202.

7. N.V. Vasil'eva, D.A. Spassky, I.V. Randoshkin, E.M. Aleksanyan, S. Vielhauer, V.O. Sokolov, V.G. Plotnichenko, V.N. Kolobanov, A.V. Khakhalin // Optical spectroscopy of Ce³⁺ ions in Gd₃(Al_xGa_{1-x})₅O₁₂ epitaxial films / Materials Research Bulletin, 2013, 48, 4687-4692.
8. V. Nagirnyi, E. Aleksanyan, G. Corradi, M. Danilkin, E. Feldbach, M. Kerikmäe, A. Kotlov, A. Lust, K. Polgár, A. Ratas, I. Romet, V. Seeman // Recombination luminescence in Li₂B₄O₇ doped with manganese and copper / Radiation Measurements, 2013, 56, 192-195.
9. Eduard Aleksanyan, Marco Kirm, Sebastian Vielhauer, Vachagan Harutyunyan // Investigation of luminescence processes in YAG single crystals irradiated by 50 MeV electron beam / Radiation Measurements, 2013, 56, 54-57.

Monographs, textbooks, etc

Meeting's proceedings

1. Eduard Aleksanyan, Sebastian Vielhauer, Eduard Feldbach, Marco Kirm, Aleksei Kotlov, Henri Mägi, Vitali Nagirnyi, Ergo Nõmmiste and Sergey Omelkov // Luminescence Spectroscopy under VUV Excitation at DESY and MAX-IV Lab – Past, Present and Future / 2013

INFORMATION ON THE TEAM MEMBER

Hakobyan Narek Areg	
Date of Birth:	1987 February 12
Selected Education:	Yerevan State University, Faculty of Physics, PhD Program, 2010-2014, Higher Diploma in
Degree:	None
Title of the last thesis, Specialty Code, year and place of defense:	Modeling of Efficient Filtration of Radioactive Aerosols via Basalt Fibers
Affiliation and Position:	Ministry of Education and Science of RA - "A.Alikhanyan National Laboratory (Yerevan Physics Institute)" Foundation of MES RA, researcher
E-mail:	h.narek@yerphi.am
Number of publications registered in the System:	6
Total number of monographs and publications in Compendiums registered in the System:	0
Number of meeting's materials in proceedings including abstracts registered in the System:	4
Number of Grants from RA MES SCS and other sources registered in the System:	1

Publications in line with the current project objectives (up to 10)

Articles in scientific journals

1. Hrant N. Yeritsyan, Vachagan V. Harutyunyan, Aram A. Sahakyan, Sergej K. Nikoghosyan, Agasi S. Hovhannisyan, Norair E. Grigoryan, Karen Sh. Ohanyan, Eleonora A. Hakhverdyan, Narek A. Hakobyan, Vahan A. Sahakyan // Space Environment Simulator for Testing of Materials and Devices / Journal of Modern Physics, 2013, 4, 180-184.
2. Norik E. Grigoryan, Hrant N. Yeritsyan, Vachagan V. Harutyunyan, Narek A. Hakobyan, Eduard A. Aleksanyan, Vahan A. Sahakyan // Scattering of Conduction Electrons on the Static Deformation Raised by Irradiation in n-GaP Crystals / Journal of Modern Physics, 2015, 6(13), 1935-1941.
3. N.A. Hakobyan // Introduction to Basics of Submicron Aerosol Particles Filtration Theory via Ultrafine Fiber Media / Armenian Journal of Physics, 2015, 8 (3), 140-151.
4. VV Harutyunyan, NA Hakobyan, EM Aleksanyan, EA Akhverdyan, VA Atoyan, VB Gavalyan, VS Baghdasaryan, MG Vardanyan, KI Pyuskyulyan // PHYSICAL PROPERTIES OF MODIFIED HIGH-EFFICIENCY SYSTEMS ON THE BASIS OF SUPER-THIN BASALT NANOSTRUCTURES / Armenian Journal of Physics, 2015, 8(2), 91-101.

Monographs, textbooks, etc

Meeting's proceedings

1. Hakobyan N.A, Harutyunyan V.V., Atoyan V.A, Pyuskulyan K.I // Characteristics of Radionuclide Aerosol Filtration High-Efficiency Systems on the Basis of Ultrafine Modified Basalt Fibers / 2015
2. N.A. Hakobyan // Constant Function Search from Set of Functions via Deutsch and Grover Algorithms Combination, / 2013
3. Harutyunyan V.V., Hakobyan N.A., Hakhverdyan E.A., Baghdasaryan V.S., Sahakyan A.A., Hovhannisyan A.S., Atoyan V.A., Avakyan A. N. // Functional Properties of Diamond Elements And Their Application In Extreme Conditions / 2013
4. Harutyunyan V.V., Hakobyan N.A., Hakhverdyan E.A., Yeritsyan H.N., Grigoryan N.Y., Sahakyan A.A., Nikoghosyan S.K., Atoyan V.A., Hovhannisyan A.V., Gevorgyan A.A. // Radiation-Modified Natural Zeolites for the Disposal of Radionuclides / 2013

INFORMATION ON THE TEAM MEMBER

Grigoryan Norik Enok	
Date of Birth:	1946 May 22
Selected Education:	Yerevan State University, Physics, PhD Program, 1963-1968, Candidate of Science
Degree:	Candidate of Physico-Mathematical Sciences
Title of the last thesis, Specialty Code, year and place of defense:	
Affiliation and Position:	Ministry of Education and Science of RA - "A.Alikhanyan National Laboratory (Yerevan Physics Institute)" Foundation of MES RA, Optical and spectroscopy group leader
E-mail:	norair@mail.yerphi.am

Number of publications registered in the System:	11
Total number of monographs and publications in Compendiums registered in the System:	0
Number of meeting's materials in proceedings including abstracts registered in the System:	0
Number of Grants from RA MES SCS and other sources registered in the System:	0

Publications in line with the current project objectives (up to 10)

Articles in scientific journals

1. Hrant Yeritsyan, Aram Sahakyan, Vachagan Harutyunyan, Sergey Nikoghosyan, Eleonora Hakhverdyan, Norair Grigoryan, Aghasi Hovhannisyanyan, Vovik Atoyanyan, Yeghis Keheyan, Christopher Rhodes // Radiation-modified natural zeolites for cleaning liquid nuclear waste (irradiation against radioactivity) / Nature: Scientific Reports, 2013, Scientific Reports 3, Article number: 2900.
2. H. N. Yeritsyan, A. A. Sahakyan, N. E. Grigoryan, V. V. Harutyunyan, V. M. Tsakanov, B. A. Grigoryan, A. S. Eremyan and G.A. Amatuni // Journal of Electronic Materials, 2016, 46(2), 841-847.
3. Hrant N. Yeritsyan, Aram A. Sahakyan, Sergey K. Nikoghosyan, Vachagan V. Harutyunyan, Karen Sh. Ohanyan, Norair E. Grigoryan, Eleonora A. Hakhverdyan, Aghasi S. Hovhannisyanyan, Vahan A. Sahakyan, Kamo A. Movsisyan, Artur V. Hovhannisyanyan // In-Situ Study of Silicon Single Crystals Conductivity under Electron Irradiation / Journal of Modern Physics, 2012, vol. 3, no5, pp. 381-385.
4. V.M. Tsakanov, R.M. Aroutiounian, G.A. Amatuni, L.R. Aloyan, L.G. Aslanyan, V.Sh.Avagyan, N.S. Babayan, V.V. Buniatyan, Y.B. Dalyan, H.D. Davtyan, M.V. Derdzian, B.A. Grigoryan, N.E. Grigoryan, L.S. Hakobyan, S.G. Haroutyunian, V.V. Harutiunyan, K.L. Hovhannesyanyan, V.G. Khachatryan, N.W. Martirosyan, G.S. Melikyan, A.G. Petrosyan, V.H. Petrosyan, A.A. Sahakyan, V.V. Sahakyan, A.A. Sargsyan, A.S. Simonyan, S.Sh. Tatikyan, G.V. Tsakanova, E. Tsovyanyan, A.S. Vardanyan, V.V. Vardanyan, A.S. Yeremyan, H.N. Yeritsyan, G.S. Zanyan // Nuclear Instruments and Methods in Physics Research A, 2016, 829, 248-253.
5. H. Yeritsyan, N. Grigoryan, V. Harutyunyan, E. Hakhverdyan, V. Baghdasaryan // Long-Time Relaxation and Residual Conductivity in GaP Irradiated by High-Energy Electrons / Journal of Modern Physics, 2014, vol. 4, pp.51-54.
6. V.V. Baghranyan, A.A. Sargsyan, A.S. Sargsyan, N.B. Knyazyan, V.V. Harutyunyan, E.M. Aleksanyan, N.E. Grigoryan, A.H. Badalyan // Armenian Journal of Physics, 2017, 10, 56-63.
7. Yeritsyan, H.N., Sahakyan, A.A., Grigoryan, N.E., Harutyunyan, V.V., Sahakyan, V.A., Khachatryan, A.A. // Clusters of Radiation Defects in Silicon Crystals / Journal of Modern Physics, 2015, vol. 6, pp. 1270-1276.
8. Hrant N. Yeritsyan, Aram A. Sahakyan, Norair E. Grigoryan, Eleonora A. Hakhverdyan, Vachagan V. Harutyunyan, Vahan A. Sahakyan, Armenuhi A. Khachatryan, Bagrat A. Grigoryan, Vardan Sh. Avagyan, Gayane A. Amatuni, Ashot S. Vardanyan // Journal of Modern Physics, 2016, 7, 1413-1419.
9. H. N. Yeritsyan, A. A. Sahakyan, V. V. Harutyunyan, N. E. Grigoryan, V. A. Sahakyan // Irradiation Enhancement of Electrical Properties of Passive Impurities in Silicon Crystals / Physical Science International Journal, 2014, 4(9), pp. 1225-1234.
10. Norik E. Grigoryan, Hrant N. Yeritsyan, Vachagan V. Harutyunyan, Narek A. Hakobyan, Eduard A. Aleksanyan, Vahan A. Sahakyan // Journal of Modern Physics, 2015, 6, 1935-1941.

Monographs, textbooks, etc

Meeting's proceedings

INFORMATION ON THE TEAM MEMBER

Badalyan Anush Hovik	
Date of Birth:	1991 January 1
Selected Education:	A. I. Alikhanyan National Science Laboratory, Yerevan Physics Institute, Applied Physics Research Department , MSc Program, 2015-2017, Master
Degree:	None
Title of the last thesis, Specialty Code, year and place of defense:	Investigation of electron structure in optical materials by visible spectroscopy, Ֆիզիկոս, 2017, A. I. Alikhanyan National Science Laboratory, Yerevan Physics Institute
Affiliation and Position:	Ministry of Education and Science of RA - "A.Alikhanyan National Laboratory (Yerevan Physics Institute)" Foundation of MES RA, Engineer physicist
E-mail:	anush.badalyan.91@mail.ru
Number of publications registered in the System:	2
Total number of monographs and publications in Compendiums registered in the System:	0
Number of meeting's materials in proceedings including abstracts registered in the System:	3
Number of Grants from RA MES SCS and other sources registered in the System:	0

Publications in line with the current project objectives (up to 10)

Articles in scientific journals

1. V.V. Baghranyan, A.A. Sargsyan, A.S. Sargsyan, N.B. Knyzyan, V.V. Harutyunyan, E.M. Aleksanyan, N.E. Grigoryan, A.H. Badalyan // Armenian Journal of Physics, 2017, 10, 56-63.
2. V.V. Harutyunyan, E.M. Aleksanyan, N.E. Grigoryan, A.A. Sahakyan, G.N. Yeritsyan, S.K. Nikoghosyan, A.S. Hovannisyan, A.H. Badalyan // Armenian Journal of Physics, 2017, 10, 69-75.

Monographs, textbooks, etc

Meeting's proceedings

1. V.V. Harutyunyan, E.M. Aleksanyan, A.H. Badalyan, N.E. Grigoryan, V.S. Baghdasaryan, A.A. Sahakyan, V.V. Baghranyan, A.A. Sargsyan // Cathodoluminescence of Thermoregulating Composite Materials / 2017
2. V.V. Harutyunyan, E.M. Aleksanyan, A.H. Badalyan, N.E. Grigoryan, V.S. Baghdasaryan, A.A. Sahakyan, V.B. Gavalyan, V.V. Baghranyan, A.A. Sargsyan // Luminescent Properties of Composite Materials in the VUV Region / 2017
3. V.V. Harutyunyan, E.M. Aleksanyan, A.H. Badalyan, N.A. Hakobyan, N.E. Grigoryan, V.S. Baghdasaryan, A.A. Sahakyan, V.V. Baghranyan, A.A. Sargsyan // V.V. Harutyunyan, E.M. Aleksanyan, A.H. Badalyan, N.A. Hakobyan, N.E. Grigoryan, V.S. Baghdasaryan, A.A. Sahakyan, V.V. Baghranyan, A.A. Sargsyan / 2017

INFORMATION ABOUT FOREIGN CONSULTANT

Marco Kirm	
Date of Birth:	1965
Country of Citizenship:	Էստոնիա
Place of work:	Institute of Physics, University of Tartu
Scientific degree:	Doctor of Science
Position:	Visiting Professor
Phone number:	+372 5342 7170
E-mail:	marco.kirm@ut.ee
Website:	

List of scientific publications (the top 10 best publications in the last 10 years)
<p>1) Narrow Band Deep Red Photoluminescence of Y₂Mg₃Ge₃O₁₂: Mn⁴⁺, Li⁺ Inverse Garnet for High Power Phosphor Converted LEDs. T Jansen, J Gorobez, M Kirm, MG Brik, S Vielhauer, M Oja, NM Khaidukov, VN Makhov, T Jüstel ECS Journal of Solid State Science and Technology. 2018, 7, R3086-R3092</p> <p>2) Luminescence properties of Er³⁺ doped zirconia thin films and ZrO₂/Er₂O₃ nanolaminates grown by atomic layer deposition. Eduard Aleksanyan, Marco Kirm, Eduard Feldbach, Kaupo Kukli, Sven Lange, Ilmo Sildos, Aile Tamm. Optical Materials, 2017, 74, 27-33</p> <p>3) Intraband luminescence excited in new ways: low-power x-ray and electron beams. Sergey I Omelkov, Vitali Nagirnyi, Eduard Feldbach, Rosana Martinez Turtos, Etienne Auffray, Marco Kirm, Paul Lecoq. Journal of Luminescence, 2017, 191, 61-67</p> <p>4) Luminescence Properties of Silicate Apatite Phosphors M₂La₈Si₆O₂₆: Eu (M= Mg, Ca, Sr). NM Khaidukov, M Kirm, E Feldbach, H Mägi, V Nagirnyi, E Töldsepp, S Vielhauer, T Jüstel, T Jansen, VN Makhov. Journal of Luminescence. 2017. 191, 51-55</p> <p>5) Silicate apatite phosphors for pc-LED applications. Marco Kirm, Eduard Feldbach, Henri Mägi, Vitali Nagirnyi, Eliko Töldsepp, Sebastian Vielhauer, Thomas Jüstel, Thomas Jansen, Nikolai M Khaidukov, Vladimir N Makhov публикации Proceedings of the Estonian Academy of Sciences. 2017, 66, 4</p> <p>6) Synthesis and luminescence properties of BaHfO₃: Pr ceramics. IE Seferis, K Fiaczyk, D Spassky, E Feldbach, I Romet, M Kirm, E Zych. Journal of Luminescence, 2017, 189, 148-152</p>

- 7) Effect of an electron beam irradiation on optical and luminescence properties of LiBaAlF₆ single crystals. IN Ogorodnikov, VA Pustovarov, SI Omelkov, M Kirm. *Optical Materials* 2017, 69, 344-351
- 8) Site selective, time and temperature dependent spectroscopy of Eu³⁺ doped apatites (Mg, Ca, Sr) 2Y₈Si₆O₂₆, T Jansen, T Jüstel, M Kirm, H Mägi, V Nagirnyi, E Töldsepp, S Vielhauer, NM Khaidukov, VN Makhov. *Journal of Luminescence*, 2017, 186, 205-211
- 9) Saturation of a Ce: Y₃Al₅O₁₂ scintillator response to ultra-short pulses of extreme ultraviolet soft X-ray and X-ray laser radiation. J Krzywinski, A Andrejczuk, RM Bionta, T Burian, J Chalupský, M Jurek, M Kirm, V Nagirnyi, R Sobierajski, K Tiedtke, S Vielhauer, L Juha. *Optical Materials Express* 2017, 7, 3, 665-675
- 10) Thermal quenching of luminescence of BaY₂F₈ crystals activated with Er³⁺ and Tm³⁺ ions. VN Makhov, TV Uvarova, M Kirm, S Vielhauer. *Bulletin of the Lebedev Physics Institute* 2016. 43, 12, 348-351

PROJECT BUDGET

Project Code: 18T-1C141

Individual Financial Support (full-time)(including taxes, AMD)									
	2018 - 7 months			2019			2020 - 5 months		
Full Name (First, Family, Patronymic)	Mothly Rate	Number of Months	Requested	Mothly Rate	Number of Months	Requested	Mothly Rate	Number of Months	Requested
Aleksanyan Eduard Mnacakan Principal Investigator - U02232FZI3SE	120.0	7	840.0	120.0	12	1440.0	120.0	5	600.0
Hakobyan Narek Areg U006834RE0HB	100.0	7	700.0	100.0	12	1200.0	100.0	5	500.0
Grigoryan Norik Enok U02366D4AEZA	90.0	7	630.0	90.0	12	1080.0	90.0	5	450.0
Badalyan Anush Hovik U0428273OC5E	90.0	7	630.0	90.0	12	1080.0	90.0	5	450.0
TOTAL INDIVIDUAL FINANCIAL SUPPORT:			2800.0			4800.0			2000.0
OTHER, including									
1. Equipments and Materials (Please list. All items over 100000 AMD must be justified in the Budget Narrative.)					2018 - 7 months		2019		2020 - 5 months
Համակարգիչ, մոնիտոր, տպիչ					400.0		200.0		0.0
Վակուումային տպիչ					0.0		60.0		0.0
Ջերմաստիճանային տպիչներ - 2 հատ					0.0		120.0		0.0
Ռ-ադիոդետալներ					0.0		120.0		0.0
Քայլային շարժիչի ղեկավարման էլեկտրոնային կառավարիչներ					0.0		80.0		0.0
Հեղուկ ազոտ					0.0		50.0		0.0
TOTAL EQUIPMENTS AND MATERIALS:					400.0		630.0		0.0
2. Travel (Please describe in Budget Narrative.)					2018 - 7 months		2019		2020 - 5 months
1) Domestic Transportation					0.0		0.0		0.0
2) Domestic Per Diem					0.0		0.0		0.0
3) Domestic Accommodation					0.0		0.0		0.0
4) International Transportation					200.0		400.0		240.0
5) International Per Diem					160.0		425.0		225.0
6) International Accommodation					210.0		260.0		260.0
7) Other Travel Expenses (visa fees, conference registration fees, etc)					0.0		0.0		0.0
TOTAL TRAVEL:					570.0		1085.0		725.0
OVERHEAD CHARGES:					58.0		85.0		47.0
TOTAL REQUESTED:					3828.0		6600.0		2772.0

Budget Narrative

1) Computer, monitor, printer – 600.000 AMD: is necessary for remote control and in-situ monitoring of the experimental parameters and process of their changing via special computer software (temperature, vacuum, beam intensity, step motor parameters) as well as for processing the experiment results. 2) During the first year of project implementation Consultants visit to Republic of Armenia is envisaged. During the visit meetings with project participants as well as introduction to existing experimental equipment and facilities will be held. 3) During the second year of project implementation one of the group members will visit to Estonia - to meet Consultant to discuss the experimental results obtained in Armenia and extend further possible experiments. 4) Participation to project-related International Conference is also foreseen during the project implementation - third year. One of the members of the group will present obtained results.