STCU NUCLEAR FORENSICS EXPERTS' WORKSHOP
8-9 June Tbilisi 2009

Terahertz Generator Application in Detection Illicit Trafficking of Nuclear Materials and Threat Risk Assessment

[1]A.A.Bayramov, [2]R.M.Sardarli

[1]Institute of Physics Azerbaijan National Academy of Sciences

Email: azad.bayramov@yahoo.com

[2]Institute of Radiation Problems Azerbaijan National Academy of Sciences

Abstract

The main principles of the IAEA policy towards defense against nuclear terrorism or countering other threats to security are support the international community's efforts against nuclear terrorism and assistance to national authorities in dealing with consequences of nuclear terrorist attacks. Particular attention is given to eventual attacks involving the use of Radiological and Nuclear (RN) weapons. Following these concepts, the main objectives of our investigations are:

- R&D of terahertz detector on the basis of layered $A^{III}B^{III}C^{VI}{}_2$ crystals for detection illicit trafficking of nuclear materials and
- performance of nuclear threat risk assessment .

Background

The systematic use of violence to achieve political ends is diverse and unpredictable. To meet the increasing need to protect civilians will require consideration of collective security not only from the military point of view, but also cooperation with multiple non-military organizations. It is important to detect critical situations and recognize dangerous conditions as early as possible, to effect appropriate reactions.

Nuclear forensics and nuclear forensic interpretation have become increasingly important tools in the fight against illicit trafficking in nuclear and radiological material.

Background

Nuclear attribution is the process of identifying the source of nuclear or radioactive material used in illegal activities, to determine the point of origin and routes of transit involving such material, and ultimately to contribute to the prosecution of those responsible.

Nuclear forensics is the analysis of intercepted illicit nuclear or radioactive material and any associated material to provide evidence for nuclear attribution. The goal of nuclear analysis is to identify forensic indicators in interdicted nuclear and radiological samples or the surrounding environment, e.g. the container or transport vehicle.

Terahertz detectors

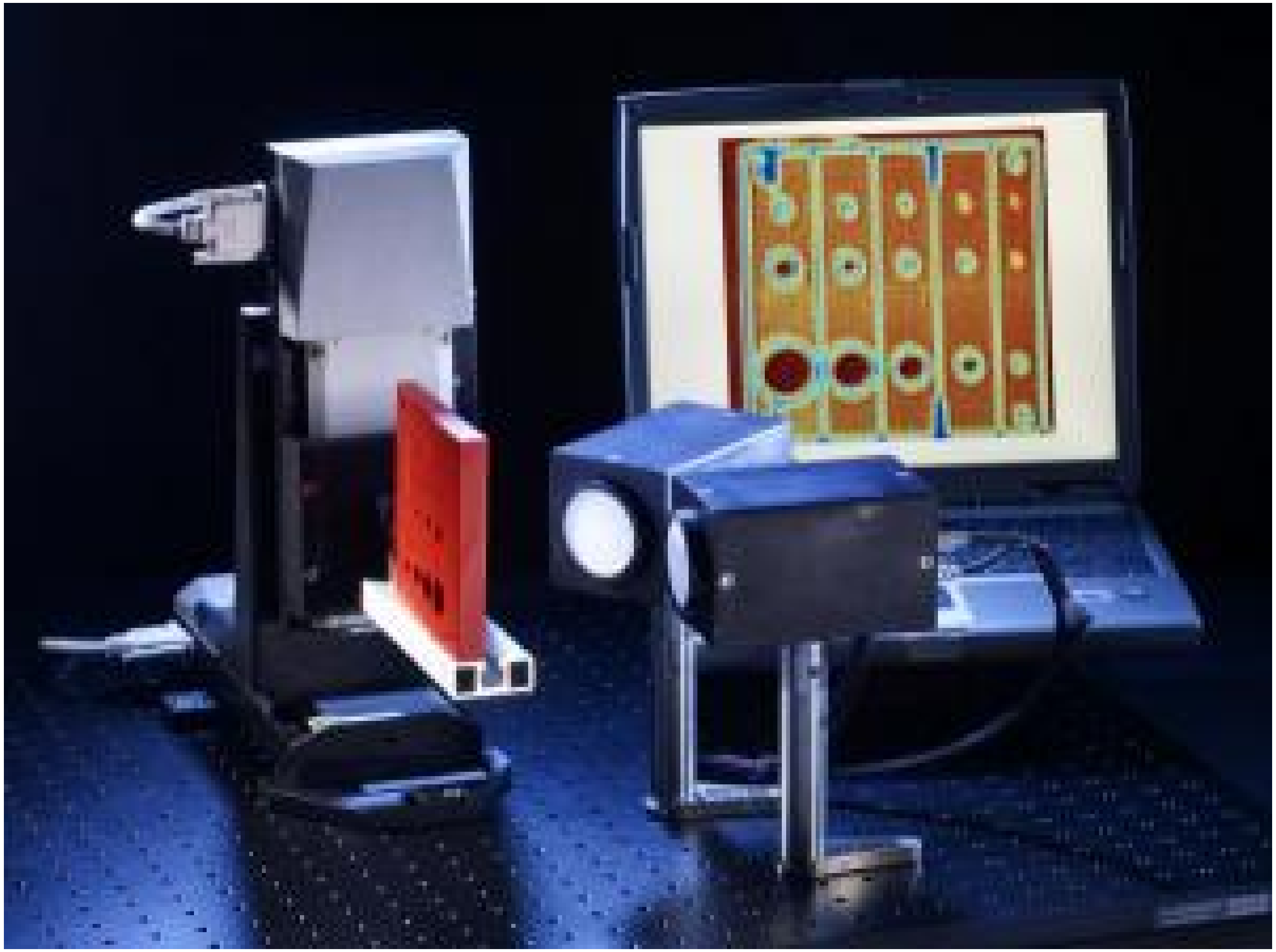
The Terahertz range of the electromagnetic radiations frequencies (from 300 GHz up to 3 THz) have been studied extensively in recent years, because this range was not investigated before with modern optoelectronic tools, and because numerous interesting applications are foreseen in security, biology, medicine, sensing in industry, physico-chemical applications, environment, and so on. Most of these applications are based on the fact that several materials are transparent for THz radiations, while they are opaque in the visible or in the infrared. Also, many molecules and materials show typical spectral signatures in the THz range, due to roto-vibrations of the whole molecules, making possible an accurate identification of the molecules. In addition Terahertz radiation is not ionizing and thus are well adapted to people inspection. Also, terahertz radiation can be used in remote identification of the explosives, dangerous chemical and radioactive substances, etc.

Terahertz detectors

Analysis of the Terahertz spectrum is one of the critical technologies for defence against suicide bombers and other nuclear terrorist activities. Terahertz radiation penetrates through most non-metallic and non-polar mediums, allowing detection of concealed materials hided in packaging, corrugated cardboard, walls, clothing, shoes, book bags, pill coatings, etc.

Terahertz detectors

Fig.1 Mobile terahertz generator



Terahertz detectors

Fig 2. Photo a man in terahertz waves

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Terahertz detectors

Fig 3. TADAR installation (© Farran Technology 2005)

Terahertz detectors

So, the objectives of our these investigations are the growth of composite structures on the basis of layered semiconductors of the $A^{III}B^{III}C^{VI}_2$ family and R&D of a Terahertz generator (detector) on the basis of nanostructures of layered ferroelectrics and application of Terahertz generator in nuclear security systems.

Threat Risk Assessment

- The work of the IAEA is at the heart of the Global Initiative. The IAEA recommends six general nuclear security objectives: <u>performance of a risk based threat assessment</u>, establishment of appropriate legal and regulatory measures that promote nuclear security, prevention, <u>detection</u>, response, and the development of human resources.
- The aim of a nuclear security threat assessment is to better understand the existence and nature of the possible dangers presented by insiders, internal groups, and external groups that may seek unauthorized access to nuclear materials from sources inside the nation or that may try to use the nation’s transportation systems or geography as part of a illicit transport system to move contraband nuclear materials from one point to another.

Threat Risk Assessment

The threat assessment continuously compiles and examines all available information and seeks to identify risks, the individuals and groups that produce them, their capabilities, intentions, history, and possible targeting.

The threat assessment addresses not only the existence of potential terrorist groups or other illegal organizations that seek to acquire nuclear materials but also the vulnerability of such materials to theft or unlawful diversion. Nuclear materials will be processed, used, stored, and transported and each of these functions carries with it its own risks of diversion, theft, or sabotage. A good threat assessment will look at each of these risks in connection with the individuals or groups and their capabilities to overcome existing security measures designed to protect against unauthorized access.

The threat assessment will also look at potential targets within the nation that terrorists might seek to attack. Large urban areas where a nuclear blast would produce the greatest number of casualties are the most probable targets for nuclear bombs.

Threat Risk Assessment

- Due to the prevailing role of human intelligence and intent, terrorist attacks are intrinsically unpredictable events.
- Terrorist groups can prepare actions involving fissile or radioactive materials in different ways, ranging from employing radiological dispersal devices (RDD, also known as dirty bombs), sabotaging nuclear facilities and detonating improvised nuclear devices (IND). It is commonly assumed that such attacks would most likely occur within an urban area in order to maximize their impact. A given scenario is characterized by 3 factors:
- (1) kind of weapon,
- (2) target type and
- (3) target location.

Threat Risk Assessment

- The spectrum of the effects depends on the particular scenario, but it is always possible to distinguish two broad categories: effects caused by ionizing radiation and effects caused by agents other than ionizing radiations. The former include acute radiation syndrome, radiation carcinogenesis, hereditary effects, and environmental contamination. The latter include, for instance, people injuries and damage to buildings and infrastructure. Psychosocial effects belong to both categories because they are caused by the combination of a toxic hazard (ionizing radiation) with a deliberate act of violence by human beings (terrorism).
- The chain of causation through which a terrorist group pursues a nuclear or radiological attack is composed by the following steps:
- (1) choice of the target city,
- (2) acquisition of the material required to perform the attack,
- (3) deployment and activation of the weapon.

Threat Risk Assessment

- These steps indicate the elements to be considered as catalysts or disincentives for a given scenario:
- (1) value of the target city (including its symbolic and publicity value),
- (2) expected economic and human losses damage and
- 3) technical, organizational and economical efforts required for building, deploying and activating the weapon.

Threat Risk Assessment

- In order to prioritize the different scenarios in a quantitative way, the above factors must be first converted into mathematical form. Because each of the factors can be considered as an inhibiting or activating stimulus S, its perception P by the terrorist group can be obtained by invoking the Weber-Fechner law: $P \propto \ln(S/S_0)$, where S_0 is a threshold stimulus. We suggest following: (1) the preference of the terrorist group for a given scenario is directly proportional to the perception of positive stimuli and inversely proportional to the perception of negative stimuli, (2) the perceptions of different kinds of stimuli can be treated as probabilities of independent events, (3) the preference of the terrorist group for a given scenario, given by the combination (2) of all perceptions, is a measure of the rank R of that scenario.

Threat Risk Assessment

According to criterion (1)÷(3), we can write:

$R = \Pi[\ln(1+F_i)]^{n_i}$, where F_i are quantifiers of factors favoring and discoursing the attack and where the integer n_i is +1 or -1 depending on the activating or inhibiting character of F_i, respectively.

The complete expression of Risk is awfully long and large!

So, the aim of our these investigations of a quantitative criterion for ranking the different scenarios of nuclear and radiological terrorism is not to predict terroristic events but only to indicate which scenario has the higher utility from the point of view of a terroristic organization in terms of balance between factors favoring and discoursing the attack, respectively.

For these investigations we need additional sponsorship.

Partners of our investigations:

- Prof. Dr. Hans D.Hochheimer, Colorado State University, USA
- Prof. Harry E. Ruda, Centre for Advanced Nanotechnology and Department of Materials Science and Engineering University of Toronto, Canada
- Prof. Jean-Louis Coutaz, MEP-LAHC, University Savoie, France
- Prof. Dr. Wolfgang Kleemann , Universität Duisburg-Essen
  Fachbereich Physik Angewandte Physik Duisburg, Germany
- Igor Linkov, US Army Engineer Research and Development Center, USA
- Alexander M.Yemelyanov, Georgia Southwestern State University, USA

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