## LIST OF RESEARCH PROJECT/PROPOSALS

### Projects completed

Principal Investigator Dr. S. A. I Bari, Co. Investigateurs; Dr. S. M. A. Durrani; Prof. F. Al. Adel: Prof. Uwe Klein; Prof. E. E. Khawaja and Dr. J. W. Shirokoff
"A joint project on "Formulation of Zeolitic Membrane by Pulsed Laser Deposition phase I", funded by SABIC (PN 22062). **Sept. 1997-June 1999**

Principal Investigator; Prof. E. E. Khawaja, Co-Investigators; Dr. S. M. A. Durrani and A. M. Al-Shukri
"Some Energy Saving Applications of Thin Solid films". An RI internal project (PN 12064).**Sep. 1999-Nov. 2001**

Principal Investigator Dr. S. A. I Bari, Co. Investigators; Dr. S. M. A. Durrani; Prof. Uwe Klein; Prof. E. E. Khawaja and Dr. J. W. Shirokoff.
"A joint project on "Formulation of Zeolitic Membrane by Pulsed Laser Deposition phase II", funded by SABIC (PN 22062**). Dec.2001-Nov. 2002**

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Principal Investigator: S. M. A. Durrani, Co. Investigators: Prof. E. E. Khawaja and Dr. M. F. Al-Kuhaili
"Thin Film Gas Sensors", funded by KFUPM SABIC (SABIC/2001-15).
**1st April 2002 – 31st March 2004**

Principal Investigator; Dr. M. F. Al-Kuhaili, Co-Investigators; S. M. A. Durrani and Prof. E. E. Khawaja
"Development of a new method for determining the optical constants of thin inhomogeneous films" funded by KFUPM (KFUPM/PH/OPTICAL/286). **1st April 2005-31st March 2006**

### 3.1.2 Approved Proposal

Principal Investigator; S. M. A. Durrani, Co-Investigators; Dr. M. F. Al-Kuhaili and A. A. Jabbar **"**Cerium Oxide Thin Film Gas Sensor for Monitoring of Carbon Monoxide" funded by KFUPM (KFUPM/PH/CERIUM/355). **1st April 2007- 30th Sept. 2008.**

**Note:** *In 1996, and 1998 we have also submitted projects on* ***"Smart Windows for Buildings and Automobiles" to KACST****. The referees reports were excellent. However the KACST did not support the project.*

## RESEARCH PROJECTS:

I joined KFUPM in May 1991 (initially the research institute and later transferred as a policy matter to physics department in September 2004). Since then as a founding member I have been actively involved in developing the IR laser and thin film laboratories and on the same time started basic and applied research. These include:

**(i)** ***Characterization of thin films prepared by e-beam and resistive heating.*** In this regard thin films of different materials such as Ge, ZnSe, $WO_3$, ZnS, $V_2O_5$, $MoO_3$, $TiO_2$, $MgF_2$, $LaF_3$, $NdF_3$, $ThF_4$ and Sn-doped $In_2O_3$ $HfO_2$, $CeO_2$, $Er_2O_3$, $Ga_2O_3$ etc. have been prepared. The XPS, FTIR, RBS, SEM and X-ray diffraction studies of these films were performed. In this regard several projects have been completed and published more than 30 papers (please see the list of publications and projects).

**(ii)** ***Environmental studies:*** In order to utilize the knowledge and achievements which I gained from my basic research in the thin film characterization, I have designed a new experimental setup for thin film gas sensors. The whole setup was fabricated in the workshop of ERC (B-28) and physics department. After completion of the setup a project on "thin film CO gas sensor" has been completed successfully and published several papers (please see the list of projects and publications). More recently another project on $CeO_2$ CO gas sensor has been approved for KFUPM internal funding (please see list of projects). Mean while I continued improving the sensor setup, in this regards recently the automation of the setup is also completed. This will enable us to control the data acquisition system and the experimental setup remotely through the network and observe the experiment in progress.

**(iii)** ***Laser spectroscopy:*** After developing IR laser laboratory research is being conducted in the field of molecular spectroscopy, this include the study of single and multiphoton absorption of $CO_2$ laser lines by $SO_2$ and $CO_2$ molecules.

**(iv)** ***Study of laser ablated thin films:*** Thin films of phosphate glasses containing oxides of Fe, Co, Ni, Cu, and Zn were prepared by $CO_2$ laser ablation on different substrates such as quartz and KBr. The XPS and FTIR studies of these films were also performed. Furthermore we have completed two projects for SABIC (please see the list of projects). As a part of my continuous effort I establish collaboration with several internationally renowned scientists (please see International collaboration). More recently working with scientists from Academy of Sciences of Czech Republic I studied desulphurization of polymers containing sulfur by $CO_2$ laser ablation and published two papers. In addition new proposal on "development of thin film thermal switches prepared by laser ablation" has been finalized and will be submitted in due time.

It is worth mentioning that in recognition of my work; more than 80 authors have cited it and others contacted me requesting copies of my published work.

## LABORATORY DEVELOPMENT RESPONSIBILITIES:

I am in charge of IR and nuclear target preparation laboratories; this includes the Operation and Maintenance of the following systems:

1. The high power $CO_2$ laser system Lumonics model TEA-820 with two TE-820HP amplifiers and related equipment.
2. Laser ablated thin film coating unit and related equipment.
3. Thin film gas sensor experimental setup
4. Operation and maintenance of the thin film coating unit Leybold AG model UNIVEX 450 in the nuclear target preparation laboratory.
5. In addition of the above I am also involved in operation and maintenance of the thin film coating unit Leybold AG model L560 in the thin film laboratory.

## 4.3 DESIGN OF MAJOR EQUIPMENT:

In addition to the experiments, maintenance and operations of above mentioned systems; I have been involved in designing major components as per the requirement:

*Heat exchangers for high temperature gas processors (part of the high power $CO_2$ Laser system):* The supplied aluminum heat exchangers manufactured by Laser Company had water flow of @ 2.5 lit/minute, while the one designed has almost 10 lit/minute that increased the cooling and hence laser efficiency. Most important feature of this design is: instead of aluminum I used copper to overcome the problem of copper ions (present in the ERL closed loop deionized water systems) and its chemical interaction with aluminum heat exchanger, which ultimately blocked the heat exchangers after few months. In case of copper heat exchangers there would be no interaction and hence blocking. The newly designed heat exchanger was fabricated at the CAPS workshop. It is being used since 1992. Based on our achievements the manufacturer of the laser company has also started manufacturing copper heat exchangers for similar closed water systems.

*Special cooling system for high power $CO_2$ laser system:* The $\Delta p$ (i.e. difference between the chilled water supply and return lines) of CAPS building is @ 15-20 psi, while for $CO_2$ laser system the required $\Delta p$ is 40-50 psi. In this regard using the existing entirely new cooling system was designed to over come this problem by using the existing chilled water lines.

*Additional Evaporation Source for Thin Film Coating Unit:* For multilayer coatings of thin films, I have jointly designed and installed an additional evaporation source in the coating unit. The additional source made it possible to coat various layers of different materials simultaneously without breaking the vacuum and hence retaining the quality of the films.

*Rotating Substrate Holder for Laser Ablation Unit:* For laser ablated thin film coating unit a new substrate holder has been designed. In this case substrate holder is mounted on a very small dc electrical motor, whose speed is controlled with specially designed circuit. The speed of the motor controls the uniformity of the deposition. Originally the substrate was on a stationary mount and the deposition was not uniform.

*Experimental Setup for Thin film Gas Sensor:* A new experimental setup for thin gas sensors was developed. In this regards for "Thin Film Gas Sensors" gas-handling system and sophisticated measurements chamber is designed and fabricated in the workshop of ERC, where measurements for various experimental conditions will be made. Moreover recently the up gradation and automation of the gas sensing setup (including data acquisition system) is completed. This will enable us to control and observe the experiment in progress remotely through the network.

In addition to the above, small experimental setups as per requirement has also been designed.

## EDITORIAL WORK:

1. Reviewed Articles for the Arabian Journal of Science and Engineering (1993-1994)
2. Reviewed Articles (NIM-B) (1994-95)
3. Reviewed Articles for the Asian Journal of Spectroscopy (1998)
4. Reviewed Proposal for KACST, March (2005)
5. Reviewed Proposal for King Abdul Aziz University, Jeddah, January (2006)
6. Reviewed Article for Materials Science and Engineering B March (2006)
7. Reviewed Articles for IEEE Journal (Sensors) (2007)
8. Reviewed Article for Materials Science and Engineering B (2007)

## SEMINARS:

1. "Excitation of $CO_2$ Laser by RF Discharge Excitation" (1992)
   CAPS-RI, KFUPM
2. "Smart Windows for Buildings and Automobiles" (1999)
   LRS, CAPS-RI, KFUPM
3. "Thin Film Gas Sensors" CAPS-RI, KFUPM, (2000).
4. "Some applications of thin solid films" Physics Dept. KFUPM, March (2003)
5. "Monitoring of CO in Flue Gas" Research Institute, KFUPM, March (2004)
6. "Applications of Thin Solid Films" Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Pakistan August (2005)
7. "Advancements in Thin Film Gas Sensors" Physics Department, Baluchistan University, Quetta-Pakistan, July (2006)
8. "Application of thin films in monitoring of hazardous gases" Baluchistan University of Information Technology, Quetta-Pakistan, June (2006)
9. "Development of Cerium Oxide Thin Film Gas Sensor for Monitoring Carbon Monoxide" Physics Department, KFUPM, 21$^{st}$ Jan. (2007)

## INTERNATIONAL COLLABORATION

1. **Dr. J. Shirokoff, Faculty of Engineering and Applied Sciences, Memorial University of Newfoundland, Canada.** Dr. Shirokoff, an expert on SEM and XRD was formerly, a researcher at CAL-RI,. We have collaborated with him for SEM and XRD characterization of the thin film sample and as a result, we co authored many research papers with him. Even after his departure from KFUPM, we have been in touch with him for his expert opinions on SEM and XRD results.

2. **Professor D. C. Ingram, Edwards Accelerator Laboratory, Department of Physics and Astronomy, Ohio University, USA.** Prof. Ingram is an expert on the RBS (Rutherford Back Scattering). As the RBS facility at KFUPM has been down for a few years, we sought the help of Prof. Ingram for the RBS analysis of our semiconductor-metal oxide thin films.

3. **Professor S. Akbar, Center for Industrial Sensors and Measurements, Department of Materials Science and Engineering, Ohio State University, USA.** Professor Akbar (materials scientist and visiting Professor of KFUPM) is an expert in the area of thick film gas sensors**.** Recently we embarked on the area of thin film based gas sensors**,** our collaboration and exchange of views with Prof. Akbar is all important.

4. **Professor J. Pola, Laser Chemistry Group, Institute of Chemical Process Fundamental, Academy of Sciences, the Czech Republic, Prague, Czech Republic.** Professor Pola is basically a laser chemist. He has visited KFUPM several times and during his visits, we spent a long time together. Our collaboration with Dr. Pola is in the area of thin film prepared by laser ablation. No doubt, we have had a great deal of interaction with him, and also we have co authored a few research papers with Prof. Pola.