University of North Florida, Jacksonville, FL

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Students: Nathan Walker, Bernadette, and Jason

March - Monthly Report for HASP2010

UND-UNF Payload

(1) UNF Preliminary design review (PDR) was completed. The PDR file is attached with this report.
(2) UND-UNF team made a video teleconference to review and discuss the PDR on March 25, 2010 during 9.00 to 12.0pm. Both team members, faculty members, and some of HASP2008 and HASP2009 students were participated and discussed all major issues. It was a fruitful video teleconference.
(3) UNF team started fabrication of nanocomposite gas sensors. Fabrication parameters are under tuning and optimization.
(4) Critical design review (CDR) will be submitted next month.
(5) Purchasing of components and payload body parts is going on.
(6) HASP plate was received from Dr. Guzik.

HASP2010

Preliminary Design Review

UND-UNF Payload

Measurement of the ozone profile in the stratosphere using nanocrystalline and nanocomposite sensor arrays on a high altitude balloon platform

UNF Students Team

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UNF Faculty Advisors

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Previous Flights

The UND and UNF team performed a successful HASP2008 and 2009 balloon flight for the measurement of the ozone gas profile in the stratosphere. The nanocrystalline ITO thin film gas sensor arrays system developed by UNF was used for the detection of the ozone gas profile, while the signal conditioning and microcontroller circuits developed by the UND team were used in the ozone sensors payload. The measured ozone profile in both HASP flights closely matched with the expected theoretical profile (Fig.1).

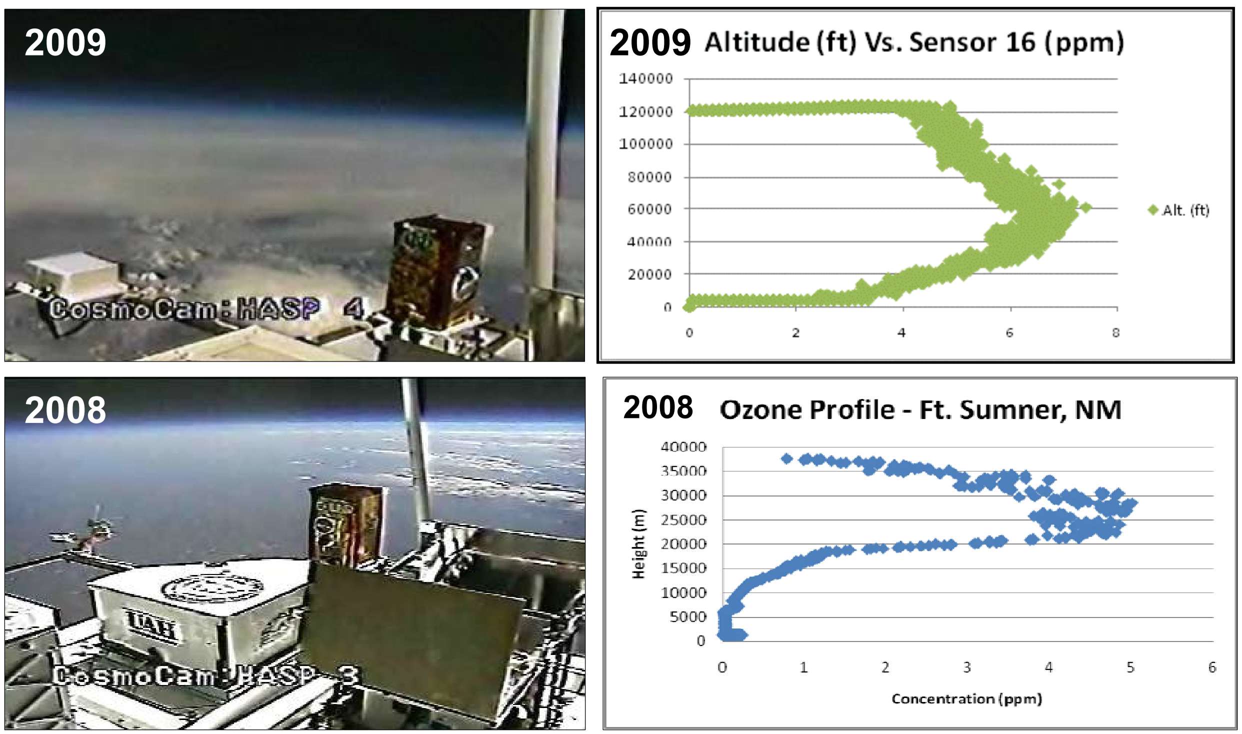

Fig.1 HASP 2008 and 2009 flights and measured ozone profiles

Mission 2010

To measure of the ozone profile in the stratosphere (Fig.2) using nanocrystalline and nanocomposite sensor arrays on a high altitude balloon platform (HASP2010).

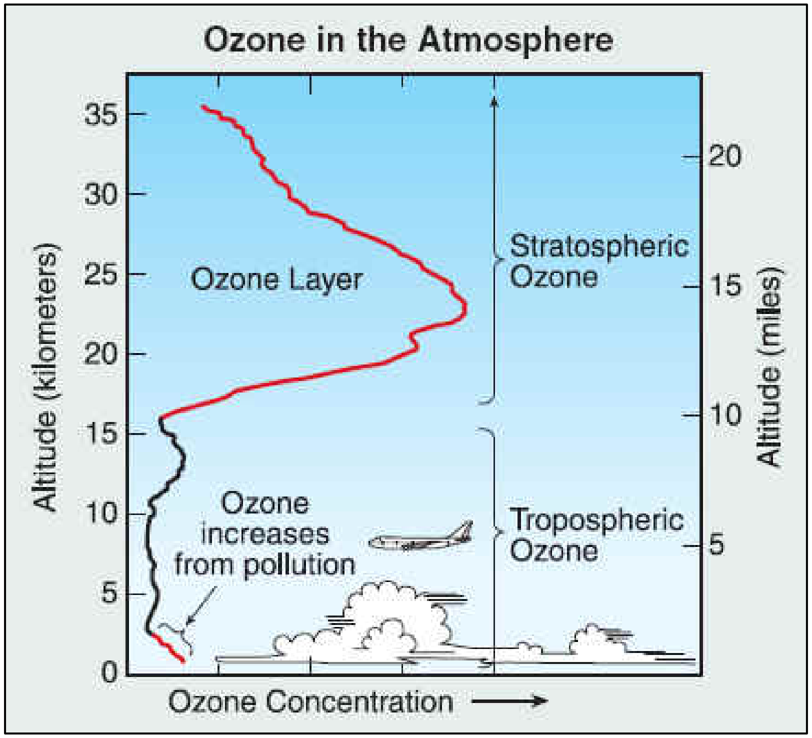

Fig.2 Ozone in atmosphere

Take care of Important Issues

- Do not use static charge sensitive tantalum capacitor.
- Avoid accumulation of static charge on PCB during handling by using body grounding.
- Use all electronic active and passive components with a wide temperature range (-40 to 65 ^{o}C)
- Perform calibrations of the temperature sensor before integration of payload.
- The temperature sensor and heater will be supplied to the UND team some time in April2010 for their testing work.
- Voltage regulator may be replaced by DC/DC converter.
- Reduce sampling rate and adjust the sampling rate to be at par with the speed of balloon.
- Develop the software for the microcontroller and protocol for communication before integration of payload.
- Correct all previous flight software problems.
- Develop a new program to convert RAW data file into an EXCEL file.
- Use nanocomposite sensor arrays to improve the sensitivity of detection of ozone and the temperature stability.
- UNF team will provide the calibration plots and set of sensor arrays to UND team well in advance.
- Avoid any loose connections of wire, cable, temperature sensor, and PCB. Add additional fastener in addition to the hot glue.
- Apply cross check verification

How Ozone Gas Sensor is Working?

The electrical resistance of ITO gas sensor increases as the concentration of ozone gas increases. Upon adsorption of the charge accepting molecules at the vacancy sites, namely oxidizing gases such as ozone, electrons are effectively depleted from the conduction band, leading to an increase in the electrical resistance of n-type semiconductor ITO gas sensor.

Interaction of ozone gas on surface of n-type ITO semiconductor thin film sensor

- **Oxygen vacancy (V) + Ozone (O_3) $\rightarrow$ Lattice Oxygen site + O_2**
- Vacancies can be filled by the reaction with ozone.
- Filled vacancies are effectively electron traps and
- as a consequence the resistance of the sensor increases upon reaction with ozone.

Fabrication of Sensor Arrays for HASP2010

Three types of sensor arrays will be fabricated for the comparison of their performance (Fig. 3a and b)

•Group 1 will consists of 8 sensors made of nanocrystalline ITO thin film

•Group 2 will consists of 8 sensors made of nanocomposite organic layer and nanocrystalline ITO thin film

•Group 3 will consists of 8 sensors made of nanocomposite inorganic layer and nanocrystalline ITO thin film

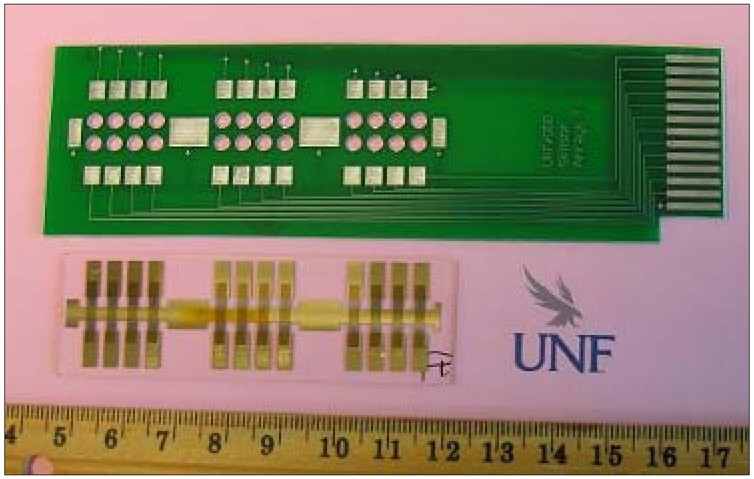

Fig. 3a Sensor array and interface PCB

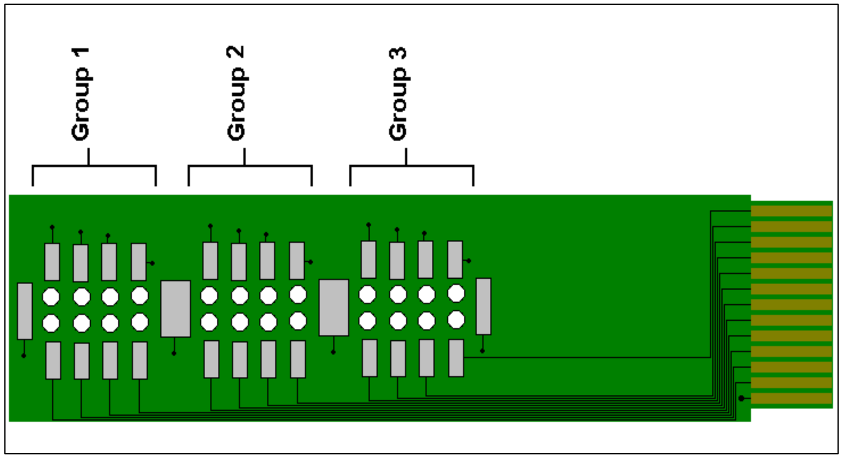

Fig. 3b The proposed sensor array attached with the interface PCB

•Currently, UNF team is working over to find the best organic and inorganic layers over nanocrystalline ITO to make the best nanocomposite sensor.

Fabrication of Sensor

•Fabrication of sensor arrays are going on using the thermal evaporation techniques.

•Sensor arrays will also fabricated by newly purchased an electron beam evaporation technique.

•High vacuum direct thermal evaporation system (Fig. 4a) is currently using for the fabrication work

•High vacuum electron beam evaporation system (Fig. 4b) will be used for the fabrication of nanocomposite inorganic-ITO sensor arrays from third week of April 2010.

Fig.4a Thermal Evaporation System

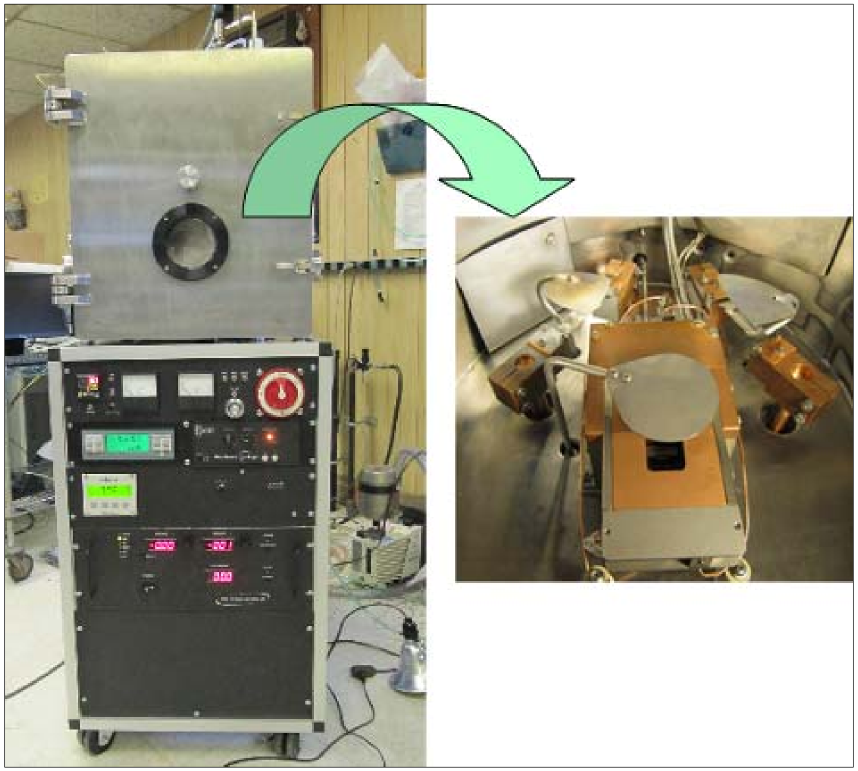

Fig.4b Electron beam evaporation system

Testing and Calibration of Sensors

•Electrometers (Fig.5a) and a data logger (Fig.5b) will be used for the testing and calibration of sensors.

•An ozone generator (Fig. 5c) and digital ozone sensor meter (Fig. 5d) will be used for the calibration of ozone sensors.

•Calibration plots and linear trend line equations will be provided to the UND team.

Surface and Chemical Analysis of Sensors

Fig.6 ESEM+EDAX

•After fabrication of sensors, the surface morphology of sensors are tested using an Environmental Scanning Electron Microscope (ESEM, FEI make, Quanta D200), while the chemical composition of sensors are tested using an Energy Dispersive Analysis of X-rays (EDAX) instrument attached to the ESEM.

•Sensors will be tested using ESEM+EDAX before and after the flight balloon flight in order to identify any damage of surface of sensors as well as change in the chemical composition.

Sensor Box

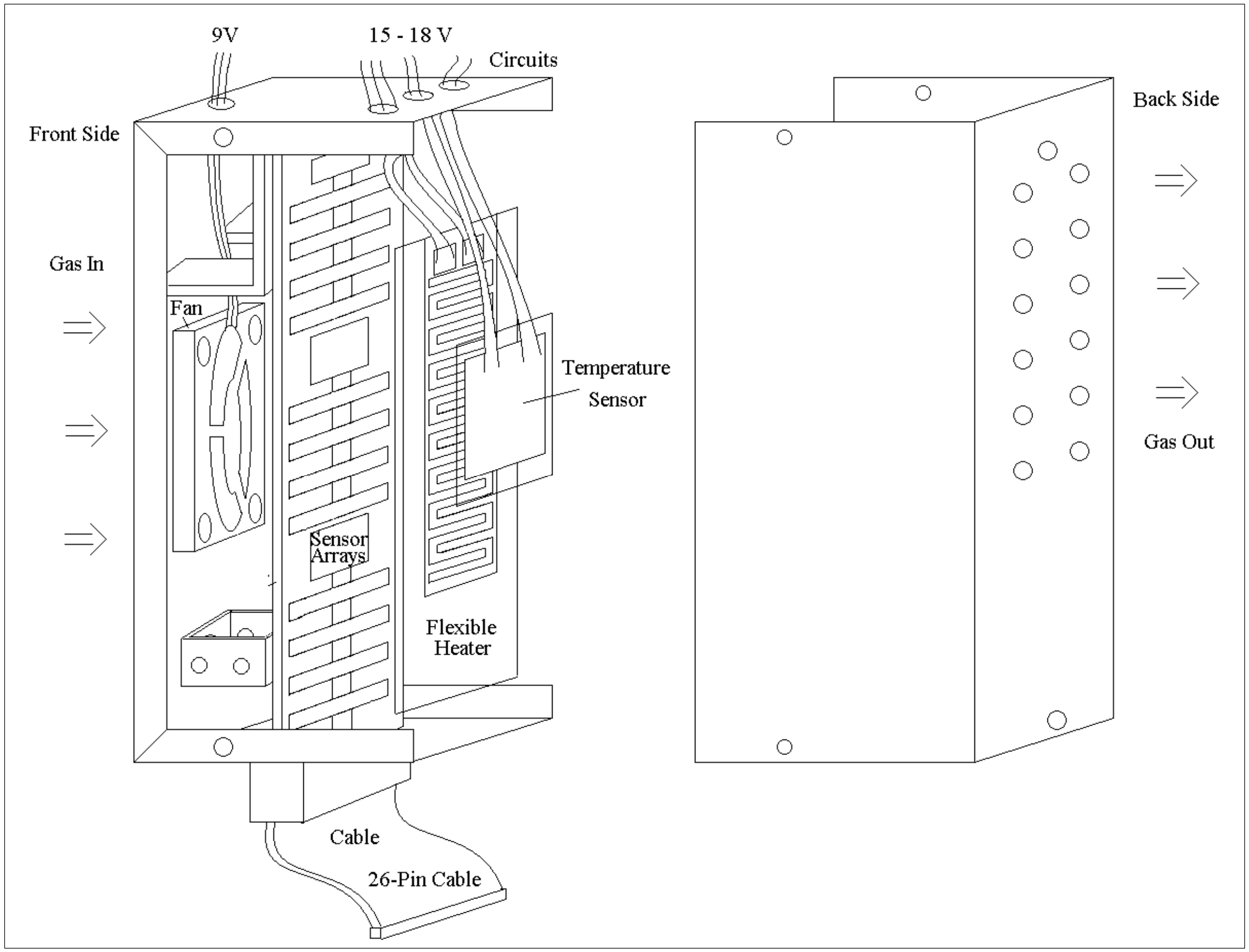

Fig.7 Schematic diagram of sensor box.

Flexible Heater (Omega make KHLV-0502/10-P) , Fan (40 or 50mm Brushless 9-12VDC, 8.00-10.00cfm)

Temperature Sensor (May be LM135 /335)

Payload Design and Body

Payload Requirements

- The dimensions of payload should be 150mm x 300mm.
- The weight of the payload should be a maximum of 3.0kg.
- UNF team received HASP the mounting plate (Fig. 8a)

Structure of Payload

- HASP2009 payload body will be fabricated as per the design developed by Kai and UND team (Fig.8b)
- The payload frame structure will be made of Al 6061, and the walls of payload will be PVC.
- A thermal blanket will be used to cover the payload to improve the thermal insulation (Fig.8c).
- The green wall will be used for mounting of the UNF sensor system box.

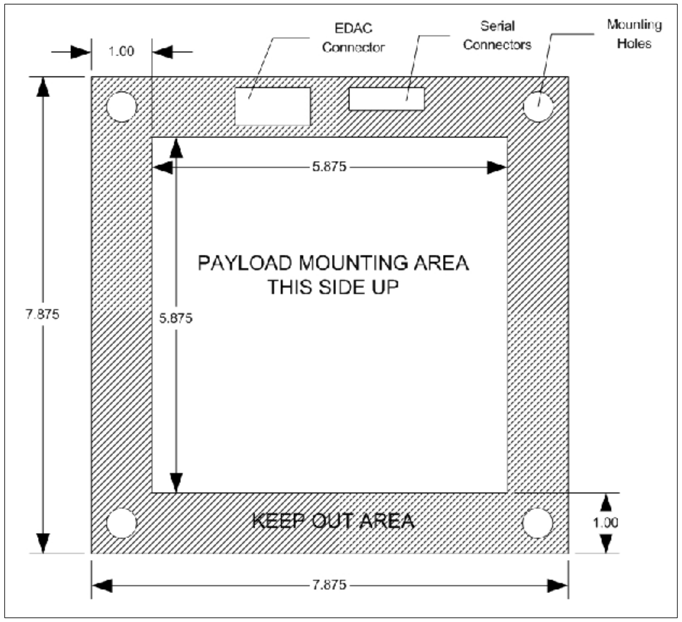

Fig. 8a HASP mounting plate

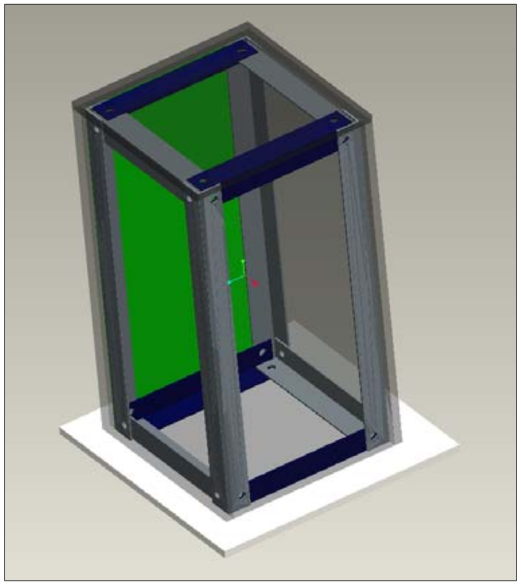

Fig.8b Payload body

Fig.8c Thermal blanket (golden color) on Payload body

Pre Flight Testing of Sensor Arrays

(i) Calibration of temperature sensor

(ii) Testing of heater and fan power consumption

(iii) Calibration of sensor arrays and determination of trend line equations

(iv) Surface analysis and chemical composition of sensor arrays

(v) Determination of stability of sensor arrays

(vi) Testing of sensor arrays at the different temperature and pressure.

(vii) Interfacing of sensor arrays with the UND electronic circuit board.

(viii) Testing of payload in the UNF and UND lab and output data

(ix) Cross check and verification of sensor arrays, circuit board and software

(x) Thermal-Vacuum test, Testing of payload communication link with HASP computer at Palestine, TX, check software and data stream

Post Flight Testing

(i) Inspect the recovered payload, sensor box and circuit board

(ii) Measure the electrical resistance of all sensors and check calibration equations

(iii) Examine surface of sensors using ESEM and determine chemical composition of sensors using EDAX

(iv) Find out any failure and make failure analysis

UNF Team

Nathan Walker

- An undergraduate electrical engineering student and was an active participant in the 2008 and 2009 HASP effort. Nathan will fabricate the payload body and mount the sensors box in the payload and help in testing the printed circuit board. He and Jason will also fabricate the sensor arrays and integrate the sensors with the flexible heater, temperature sensor and fan into the payload body .

Bernadette Quijano

- An undergraduate mechanical engineering student and was an active participant in the 2009 HASP effort. She will be responsible for designing the payload body, testing and calibrating the sensor arrays with ozone gas under different temperature and pressure conditions, and determining trend line equations. She will also perform the post flight data analysis and report work.

Jason Saredy

- A graduate physics student and was involved in the 2008 and 2009 HASP effort. He will fabricate the gas sensors arrays. Jason will also examine the sensors with the ESEM and EDAX.

Ryan Shore

- A senior electrical engineering student. He will perform all the cross verification of the electronic and software systems developed by the UND team. He will also perform post flight payload testing and analysis of the payload data.

Dr. Nirmal G. Patel

- A faculty advisor for the development, fabrication and testing of the sensor arrays and payload.

Dr. Choi Chiu

- A faculty advisor for the electronic circuit and software development and testing of the sensor arrays and payload.

Financial Situation

- Dr. Patel and his team team have funding from the Florida Space Grant Consortium (FSGC) up to the end of May 2010. Dr. Patel has already requested FSGC extension of funding of the project up to the end of October 2010.
- We are currently seeking additional funding for travel and consumables.