ANSER Center research is focused on developing new approaches to solar energy conversion. We seek to develop a fundamental understanding of how specific molecular and supramolecular structures can be used to harvest light energy, promote efficient photoinduced charge separation, and store that energy to perform useful work. ANSER Center PI’s are developing artificial photosynthetic systems for solar fuels, new materials for organic photovoltaics, and hybrid, organic-inorganic materials for dye-sensitized solar cells. Electron transfer reactions are essential to the efficient capture and storage of excitation energy following light absorption by these complex systems. Unambiguous identification and structural characterization of the short-lived intermediates produced by energy and electron transfer are critical to determining the mechanisms of solar energy capture, charge separation and storage in these molecular systems.

Time-Resolved Electron Paramagnetic Resonance (TREPR) spectroscopy is at the core of understanding the relationship of energy and charge transfer dynamics to molecular structure within solar energy conversion molecules and materials. Dr. Ranaan Carmielli is an expert in this technique and has provided leadership in servicing the extensive network of collaborations among ANSER PIs, the energy research community at Northwestern, and the global solar energy research community. He has engaged in several collaborative projects during this period. Collaborative work with the Marks group focused on charge generation in new materials for organic photovoltaics. Work with the Hupp group engaged in understanding radical formation in metal-organic frameworks for gas separation and catalysis related to energy storage and solar energy conversion. Research with the Stoddart group focused on new nanomaterials, which function as charge carriers and molecular switches. Work with the Hoffman group focused on electron transfer with cytochromes. Work with the Wasielewski group included photo-initiated charge separation in self-assembling materials for solar fuels and for organic photovoltaics. Collaborations with the Lewis group investigated photo-initiated long distance charge transport in synthetic DNA. Collaborations with other ANSER PIs outside Northwestern included work on metal complexes for photochemical water splitting with the Brudvig and Crabtree groups at Yale, and preliminary investigations of di-iron catalysts for proton reduction to hydrogen.

Dr. Carmielli also engaged in instrument development by designing a Q-band (34 GHz) microwave bridge for the new Q-band EPR spectrometer that was subsequently built with ANSER funds obtained when ANSER was chosen as a DOE Energy Frontier Research Center. He also developed simulation codes that have greatly aided our ability to analyze the TREPR spectra generated by all the collaborative projects within which he was (and still is involved).

Given the fact that we were able to retain Dr. Carmielli’s services during the period just prior to the arrival of the DOE EFRC funding, Dr. Carmielli was subsequently appointed a Research Assistant Professor and continues to provide a high level of expertise in EPR spectroscopy to our growing number of collaborators both within and outside Northwestern, helping to make Northwestern a world center for these types of measurements that are critical for characterizing new energy-related materials.