Modern electronics is dominated by inorganic, mainly silicon semiconductors. There exists, however, a whole family of semiconductors of different type, namely organic semiconductors. They are not competitive with the inorganic ones but it is possible to find technological domains in which they are being successfully applied. *Organic light emitting diodes* (OLEDs) can be considered as a spectacular example. OLEDs are basic elements of color screens of different type. These devices convert electrical energy into radiation. As a result of electrical excitations the so called *"excitons"* are formed. Annihilation of an exciton gives rise to emission of one photon, under one condition, however. This has to be a singlet exciton. Unfortunately, out of four generated excitons only one is of singlet nature, the remaining three are triplet excitons which do not generate light. This means that the maximum quantum efficiency of an purely organic diode cannot exceed 25% since 75% of excitons are useless in this respect. In our research proposal we plan the synthesis of new organic semiconductors constituting a triade of the following type: *donor-bridge-acceptor* (DBA). Preliminary results indicate that some designed by us triads are capable of converting triplet excitons into singlet ones, in other words *"useless"* excitons into *"useful"* ones, improving in this manner the quantum efficiency of a diode. The effect is called *"thermally-activated delayed fluorescence"*. In addition, in some of the designed triads charge separation can occur upon photoexcitation leading to the generation of so called *"spin correlated radical pairs"* which can be considered as the smallest memory elements of a molecular computer.

In the case of organic semiconductors packing of individual molecules in crystals or monolayers, or in other words their "supramolecular organization", is of crucial importance for chemical and physical properties of such layers. Using scanning tunneling microscopy (STM) we plan to obtain images of individual molecules in the monolayer and elucidate the nature of interactions between them which govern the type of the supramolecular structure.

In addition to purely organic semiconductors we will investigate inorganic semiconductors nanocrystals *i.e.* objects of few nanometers size. Ternary nanocrystals consisting of silver, indium and sulfur (Ag-In-S) and quaternary ones, additionally containing zinc (Ag-In-Zn-S), will be tested for the first time as new photocatalysts, which under photoexcitation catalyze (or in other words "promote") industrially important reactions of ketones and aldehydes reduction to alcohols. Nanocrystals of inorganic semiconductors have a tendency to agglomerate. For this reason their surface is functionalized with organic molecules, called *"ligands"* which increase their stability. To some ligands present on the nanocrystal surface biologically active molecules can be attached. This opens up a new area of the design of new drug nanocarriers. We plan to fabricate nanocarriers of the following type: i) first transferrin, a protein capable of recognizing tumor cells is attached to nanocrystal ligands; ii) in the next step doxorubicine, an anticancer drug, is attached to transferrin. The resulting nanoconjugate: nanocrystal/ligand/transferrin/doxorubicine can selectively recognize tumor cells and transport doxorubicine to it. Moreover it can emit near infrared (NIR) radiation which is not absorbed by body fluids and body tissue. Thus, it is possible to closely follow the transport of the nanoconjugate in the organism by detection its radiation.

We also plan to investigate Ag-In-Zn-S nanocrystals in which primary inert ligands are exchanged for semiconducting ones. Such conjugates are called *"hybrids"* because they consists of two parts (organic and inorganic) of distinctly different nature. Hybrids of inorganic nanocrystals with semiconducting ligands may exhibit unusual luminescent properties. For example, as a result of charge and energy transfer from the inorganic core to the semiconducting ligand, the original luminescence of the inorganic may totally disappear with concomitant appearance of the ligands luminescence of higher energy. Thus, such hybrids can be considered as a new type up-converters.

To summarize, in our research project we plan to elaborate three types of novel materials, elucidate their chemical and physical properties and to apply them as electroluminophores, photocatalysts, drug nanocarriers and up-converters.