The most intense electromagnetic waves law european essay

Law

startcomponent fys_theo-teun_polish-academyenvironment travellayoutabbreviation{SEM}{Scanning Electron Microscope}abbreviation{MBE}{Molecular Beam Epitaxy}abbreviation{TEM}{Transmission Electron Microscope}abbreviation{ALD}{Atomic Layer Deposition}abbreviation{STM}{Scanning Tunneling Microscope}abbreviation{AFM}{Atomic Force Microscope}abbreviation{UV}{Ultra Violet}abbreviation{IR}{Infra Red} eport{Institute of Physics, Polish Academy of Science}{date[d= 25, m= 11, y= 2012]}{Theo Cremers & Teun Custers}section{Expectation and impression}My expectations when visiting the Polish academy of science were quite limited. I really hadn't looked into the facilities beforehand, so I didn't know what to expect. This way I was pleasantly suprised by the variety of research that we were being showed. Of the quality of the research I really didn't have any doubt that it would be of very high standard. The researchers showing us around were younger than I expected. All in all it was a interesting facility and I learned a lot about the practical side of physics. section{Optical Spectroscopy}Our tour of optical spectroscopy actually started with a visit to the lab of dr. T. Krajewski, who mainly focuses on creating ZnO layers using ALD (infull{ALD}cite[ALD: overview]). In this case typically on organic substratescite[ALD: organic]. We entered the lab (with our plastic shoes on) and were shown three reactor chambers for use in ALD. Two of them I later identified as the Savannah-100 ALD reactor and the F-120 reactor from Microchemistryfootnote{The first ALD reactor to be sold commercially back in 1988}, both can be used to make ZnO thin films. The process of ALD starts with preparing a suitable substrate. These wafers are typically made as smooth as possible, since the deposited film will take over any defects of the surface. First the reaction chamber is purged by an inert gasfootnote{typically N$_2$cite[ALD: exp]} to remove any undesired reactants. Then the substrate is exposed to gasseous molecules that will result in the desired film. The molecules have only a select few places to react, and after a while the substrate is saturated. The result is a monolayer of molecules, for instance ZnO. If a multilayered film is desired, the reactor will undergo a cyclic process of purging and adding new gasseous molecules. These will be molecules that can attach to the previous layer. The advantage of this technique is great uniformity in the films, as a result of a limited amount molecules attaching to the surface of the substrate. This also means that no great effort has to be made to control the amount of gasseous molecules that enter the chamber. A downside to this technique is that the process itself is pretty slow, since after each cycle the reaction chamber has to be purged. The upper limit of growth speed is around 1mum per hourcite[ALD: exp]. subsection{Measuring properties}There are a lot of different types of films that can be made, and each one can have different properties. These all have to be measured and recorded. This is where the next part of the lab comes in. This part contained several machines to measure the properties of all the deposited layers. One machine uses the quantum hall effect together with the van der Pauw techniquecite[ALD: hall] to measure the electrical resistivity and other electrical parameters. There were also optical devices used to measure the thickness of the layers. They measure the amount electromagnetic waves passing through the film at certain wavelengths. Finally, a pressure chamber was available to introduce certain gasses in a controlled fashion and measure reactions it could undergo with the layer on the substrate. Scanning the surface of the layers for defects can be achieved by use of different microscopes depending on the required resolution. All of these are available within the institute: startitemizeitem Optical microscopy: Limit of about 200 nm as it is limited by the wavelength of visible light, also called Abbe's limitcite[ALD: limit]. item TEM (infull{TEM}): The De Broglie wavelength of an electron is much smaller than that of visible light, but it still faces Abbe's limit at some point, making this technique useful up to ~100 pm scale. item AFM (infull{AFM}): Van der Waals interactions between the layer and a tip, scanning the surface, is used to map the bumps in the surface. the vertical resolution is similar to that of TEM although the lateral resolution will be lesscite[ALD: AFM]. item STM (infull{STM}): Uses quantum tunneling effects to scan a surface, reaching a resolution of ~10 pmcite[ALD: STM]. stopitemizeOptical microscopy is not really useful in this case, since the thickness of the layers themselves are in the same range as the resolution limit. Generally, using TEM or AFM suffices to find any irregularities and map the ZnO layers. But if a higher precision is required STM is available as well since the layers are conductive. With the semiconducting properties of ZnO, integrated circuits can be made using nanolithography. This process restricts the areas in which the ZnO will form on the substrate. This can be achieved in a variety of ways most often utilizing electromagnetic wavescite[ALD: nlg]. With this dr T. Krajewski is testing if ZnO could be a suitable material to make Schottky diodescite[ALD: schottky]. ZnO has the advantage that it can be grown at relatively low temperatures ($60^{cdot}C - 200^{cdot}C$)

which is necessary when growing on an organic substrate. The goal is to make a schottky diode with a high rectification ratio, defined as the forward current over the reverse current. subsection{Luminescence}Moving on to a different lab, where the real optical spectroscopy takes place. For example a laser beam of either UV , IR or visible wavelengths which passes through a beam splitter with one part of the beam used as a reference signal. The other half is beamed through a sample which absorbs only a select few wavelengths and transmits the rest. The electromagnetic waves that pass through are compared to the reference signal, giving the absorbed wavelengths as a result. Using a system of tubes, liquid helium is pumped to keep the setup cooled down to 10 K. The gaseous helium is retrieved and sent to a different part of the institute to be liquefied and re-used, since liquid helium is quite expensive. placefigure[][luminescence]{Schematic setup for measuring photo-luminescence}{externalfigure[luminescence][width= 0. 5extwidth]}Other devices use luminescence to get information out of all kinds of samples. Not only photo-luminescence can be used, electro- and chemo-luminescence can also help determining properties of certain samples. One of the simple setups for measuring photo-luminescence can be seen in in{figure}[luminescence]. An electromagnetic wave is beamed onto a sample by means of a mirror. The sample is placed in the focal point of lens B so the emitted luminescence is made into a parallel beam of light. This collimated light is then focused by lens A into either a mono- or polychromator to measure the intensity of the wavelengths. section{infull{MBE} (MBE) lab for wide band gap semiconductors}We enter the clean room of the MBE lab (with our plastic shoes on, and this time also a lab coat) under supervision of dr. H. Teisseyre. He works on creating semiconducting surfaces using MBE (infull{MBE}cite[MBE: basic]), not only with ZnO but also GaNcite[MBE: gan]. In MBE one or more molecular or atomic beams are used to grow a desired layer on a crystalline substrate. Two reactors connected to each other are used in this lab for MBE one of which can be seen in in{figure}[MBE: chamber]. placefigure[][MBE: chamber]{MBE reactor chamber.}{externalfigure[MBE][width= 0. 3extwidth]}These have a wide variety of different devices attached to them including a plasma source of nitrogen or oxygen, making it one of the more advanced MBE devices in the world. These chambers can reach very high vacuum, up to 10^{-11} Torrfootnote{1 Torr = 133. 322 Pa}. This is necessary to keep the substrate from being contaminated since the MBE process itself is quite a slow one. You definitely don't want any contamination when trying to create GaN substrates which are very expensive at the moment: A 2-inch substrate of GaN costs about \$1900 compared to \$25-\$50 for a 6-inch Si substratecite[MBE: price].% het wordt in dit stukje niet duidelijk wat molecular beam epitaxy is, kun je dat in een paar zinnen uitleggen? in het stukje van teun kon ik het ook niet goed vindensection{Spintronics lab}This is the lab of prof. G. Grabecki. His work is a little bit more on the theoretical side. We were shown their refrigerator devices for cooling small circuits down to ~0. 007 mK. It is called a Dilution Refrigerator and it uses the properties of ^{4}He and ^{3}He to cool even below the boiling point of heliumcite[Spin: fridge]. The process can be seen in in{figure}[dilution]. The less dense concentrated ^{3}He will float on top of the mixed ^{4}He and ^{3}He. The concentrated phase has a higher enthalpy than the diluted phase. But ^{3}He can pass from the concentrated to the diluted phase, and is forced to do so by the distiller. It uses heat to remove only the pure ^{3}He and then the pump pushes the ^{3}He to be used again. This passing of ^{3}He from concentrated to diluted phase requires an increase in enthalpy, which means that thermal energy is extracted from the surrounding system. This makes the mixing chamber drop down to temperatures of the mK scale. placefigure[][dilution]{A simplified dilution refrigerator}{externalfigure[dilutionfridge][width= 0. 4extwidth]}This is what we were shown, but it is doesnt directly involve spintronics. Spintronics is just a fieldof research that involves the detection and manipulation of electron spin. An good example would be quote{Spin splitting in PbTe nanostructures}cite[Spin: filtering]. In this case research was done towards the possibility of using PbTe in quantum computing devices. Lithography was used to make the samples and SEM (infull{SEM}) to map the result. Spin filtering means isolating spin-polarized currents, so the current itself carries a bit of information. Using magnetic fields, barriers can be made that only allow one type of spin throughcite[Spin: phenom]. section{X-ray spectroscopy and infull{TEM}}Finally, we had a chance to see the lab for X-ray spectroscopy and TEM. Our host this time around was prof. K. Jabłońska, who seemed very keen on showing us his work. The machine they used to measure X-ray diffraction and absorption can be seen in in{figure}[xrayz]. One well known way to deduce the thickness between crystalline layers in a solid is to measure the angle at which the most intense electromagnetic waves are scattered from the sample. According to Bragg's law certain angles will produce destructive interference between waves scattered from consecutive layers of a crystal, while at other angles these will interfere constructively. Knowing these angles allows us to calculate the spacing between the scattering planes of the crystal. placefigure[][xrayz]{X-ray chamber at the Polish institute building 9}{externalfigure[xray][width= 0. 3extwidth]}This is of course not the only way X-rays will help at determining the properties of samples. Several different techniques of measuring X-rayabsorption have existed for quite some time nowcite[XRAY: tech]. These can be used to study for example Ge Layers buried in Silicone crystalcite[XRAY: absorp]. section{Sources}placepublicationsstopcomponent