Folie1

Good morning everyone . I'd like, first of All to thank my supervisor Günter Reiss for all his time and efforts during this project today . I + co workers . and Thanks all for coming to my presentation.

I'm here today to PRESENT my Masters work . In my presentation I would like to Concentrate on All nitride Magnetic tunnel Junctions.

By the end of this Talk you will be familiar with State-of-the-art nitride manufacturing techniques.

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folie 2

It is been fantastic to live in the silicon AGE. We are given a system ,where we move electrons between Gates and Devices like transistors . Electrons are there, not there, it's a binary logic. Its an imensely powerful.You generate heat when you transfer these electrons around. but the success is not argued. Furthermore, in addition to mass and charge. There's another particle property of these electrons , and THAT is spin.

The best way to describe it is when you are dancing with your partner.

so the electron has spin which acts like a tiny BAR magnet and by using the spin, many possibilities for low-power logic , sensor and memory devices have become possible.

Folie 3

The magnetic tunnel junction is a rosetta stone of spintronic devices, providing the main way to convert between magnetic and electrical information.

To begin,Today I'd like to give you an overview of the stack

By using Epitaxial Growth, We start with a non-magnetic Substrate in my case MgO.

Let's look at this problem in a bit more detail.

The basic element of an MTJ is a sandwich of two ferromagnetic (F) electrodes separated by a thin insulating tunnel barrier(AlN is a wide-band-gap (energy gap ~6.2 eV) semi-conductor).

This junction employs Titanium nitride (TiN) (TiN is a transitionFGTetal superconductor.) as seedlayer.In addition MnN as AFM respectively.

AlN is a unique material in a sense that it has a high mechanical, thermal and chemical stability.

Iron Nitride is one of fascinating materials . Iron—one of the most common elements found on our planet, which contributes to approximately 6 percent of Earth's crust. Its abundance, low toxicity, and relative found in the production of various tools and constructions . Which make iron one of the most important elements in the history of mankind.

So my approach ist to break down complex problems into smaller work packages.

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Folie 4

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Folie 5

to explore the morphology as well as lattice-structure of thin films .

Sample preparation :

BesTec System which consists of 4 targets, 2", DC or RF mode with ultra high vacuum. Samples were obtained at either different deposition templates or at we varied the nitrogen contents into Argon.

After that

Philips X'Pert Pro MPD where i used x-ray diffractometer for x-ray reflectivity (XRR)(to ensure thickness of all samples) and The crystal structures of films were characterized by XR-Diffraction .

Now let’s make a real effort to achieve this goal!

As a starting point, i started with AlN to make sure i have an insulator.

6

Choice of Substrate for C-sapphire was favorable for the highly crystalline c-axis oriented AlN.

The example of XRD plot of AlN films . There are 5 panels in the figure, denoting the crystal orientations of 5 films that were deposited with different Temperatures and const 60% Nitrogen concentrations. The 2θ peak positions for (002) planes are clearly labeled. For example, the peak for (002) plane is at 36°. The y-axis has an arbitrary unit.

To illustrate this point, I’d like to bring your attention to this chart/graph. Which shows on the role of increasing deposition temperature towards depositing c-axis AlN.

The value of the c-lattice parameter at highest (002) plane can be caluted from Bragg's equation , where is the diffraction order n=1 ,lattice spacing d , *h*, *k*, and ℓ are the Miller indices of the Bragg plane. . Furthermore, AlN has neast values of c-lattice parameter near 600C .

7

The crystal quality of the AlN film is normally represented by its FWHM value. It should be clear that the FWHM values specifically refers to the (002) orientation. by using the FWHM of the rocking curve measurement.

So what can we learn from this?

The FWHM of the (002) diffraction peak are not changing in crystalline quality towards depositing temper of AlN thin films between 300 and 600 and getting worse at 700C.

When the temperature was further increased to 600 ∘C, the intensity of the

AlN (0002) peak decreased.

For the best speciman, full width at half maximum of (0002) rocking curve scan at 600C .

8

N2 to Ar Ratio

I would like to explain the basic reactive sputtering. It has TWO modes, which is determined by the N2/Ar ratio. At lower N2 concentration i.e., “metal mode”, Al target is slightly covered with nitride. Once N2 concentration increases, the “transition mode” occurs. The target surface becomes partially reactive with N2.

we used higher N2 concentrations to deposit highly c-axis AlN film near to the theo value.

9

one thing to keep in my mind, is that We studied the effect of N2 concentrations in the range of 20% to 80%.

also we see the strong influence of the N2 concentration on the AlN films. We notice a increase of (002) diffraction peak amplitude when the N2 concentration increased from 40to 80%. Which result in high of crystallinity at 60% nitrogen content .

For the best speciman of ALN films were at 600C and 60% n2 content.

So much for the first point, and As I said/mentioned earlier? how can we make sure that we have an insulator? 4-Transport-Measurement.

10

Remember what I said at the beginning of my talk today? Well, The junctions are prepared by lithography.

Electron beam lithography is the process of transferring a pattern onto the surface of a substrate by first scanning a thin layer of organic film (called resist) on the surface by a tightly focused and precisely controlled electron beam (exposure) and then selectively removing the exposed regions of the resist in (developing).

2- The exposed areas could be further processed for etching **with Ar- Inos .**

3- Sputter insulator

4- Remove etching mask with ultrasound

5- contact material sputtern (Ta, Au) from 50 till 60 nm .

6- bring up Resist and expoe this area ,then develop it by etching .

7- Transport Phonemena

11

The tunnel junctions were sputter deposited and then lithographically patterned . AlN was deposited by reactive sputtering from an Al target with 60% N2 and 600C and Titanium at room temperature with 20nm thickness resulting in epitaxial growth of this junction.

How can we use this to our benefit?

Tunneling possibilities? So, where do we go from here?

12

Quantum tunnelling is a paradox from the classical point of view as it enables elementary particles and atoms to permeate an energetic barrier without the need for sufficient energy to overcome it.

If two electrically conductive bodies are brought together to within a few Å, the vacuum

between them forms such a potential barrier that is small enough for the conduction elec-

trons to tunnel through. . In order for a current to flow in one direction, the Fermi levels must

be shifted relative to each other by applying a voltage.

This allows the electrons of one electrode to tunnel into the free states of the other electrode.

Here I stands for the tunneling current,, and where
U is the average barrier height, and L is the barrier width and of course a bias voltage V .

This leads directly to how i measure the transport phenomena .

13

Are you all following me so far?

I’d like now to point out one or wo interesting details.
we are interested in know the value of Junction area resistance RA   is a product of resistance of this junction multiplied by its area .

14

So what does this information tell us?

Ra is …. micom2. but caution , caution,caution

Briefly XRD and N2 arm .

Crystallographic Structure of Different Iron Nitride Phases

γ′-Fe_4N
When the atomic concentration of nitrogen with respect to iron is around 20%, the γ′-Fe_4N phase forms. This phase crystallizes in a fcc structure However, further X-ray diffraction experiments revealed and providing information on the crystalline phase. (lattice parameter a = 3.795 Å)

MnN
AFM passive elements a exchange bais.

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mention about miscalculating the deposition rate of aln at 002 orientation.

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let me try to summarize what we did?

Before I finish, let me just say how glad i am to work with all those interesting materials , enjoying the process of research, which always reminds me when i go for a run or climb a mountain , that the most joyful thing is not what you know, but what you don't know.

and now I’ll be happy to answer any questions you may have.