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PROBLEM AT HAND

- ✖ What is function of CDROM drive?
 - + Store huge data in the form of pits and lands and get it to you faithfully when demanded
 - + Data is read by using a laser (lets not worry how its written) focussed on surface of CD
- ✖ How CD looks like? How data on CD looks like under microscope?

3

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PROBLEM AT HAND

- ✖ CD and data on its surface seen under microscope



Factor
Horizontal: 1054 pixels for 130 μm 50.31
Vertical: 1056 pixels for 130 μm 50.43

- ✖ This data is read by using a laser focussed on the surface of CD by a lense in CD head.

4

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PROBLEM AT HAND

- ✖ What kind of motions specifications would be required for the reading laser and how do we achieve them?
- ✖ What other systems would be required?
- ✖ Any ideas:

5

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CD ROM DRIVE OPENED

- ✖ Lets look into the actual CD ROM drive given to you and see what solutions exists professionally
 - + Open the cover and remove the electroinc PCBs and connectors from them notice flat connectors. Why?
 - + Access the place where CD is kept and observe
 - + See the head on the surface of CD and observe
 - + Remove head from its guide rods (by removing guide rods)
 - + Without damaging components start removing very carefully electronic PCBs in the head assembly so that you can see everything inside

6

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CD ROM DRIVE OPENED

* Observations:

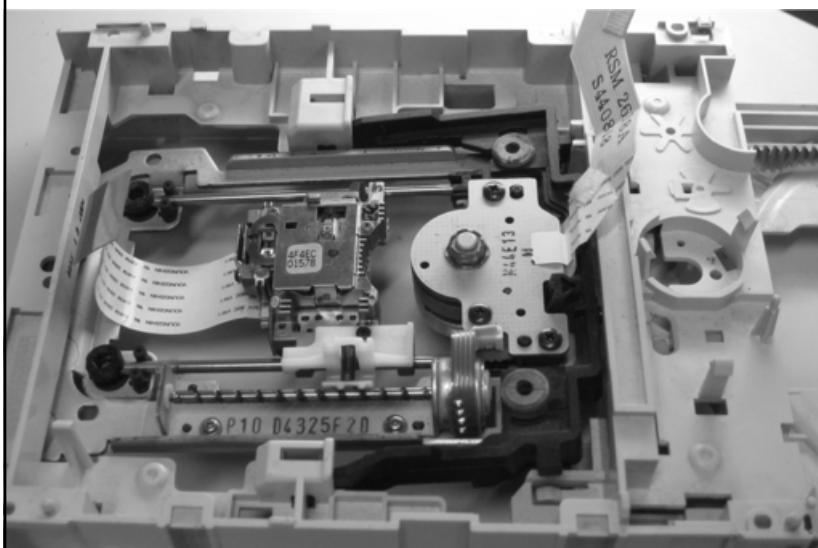
- + what different components you find in the drive?
what are they for?
- + What are the components responsible for achieving fine motion of the laser? And rotation of CD
- + Why we need these components for achieving fine positioning?

* Lets start addressing these questions from mechatronics system perspective one by one.

7

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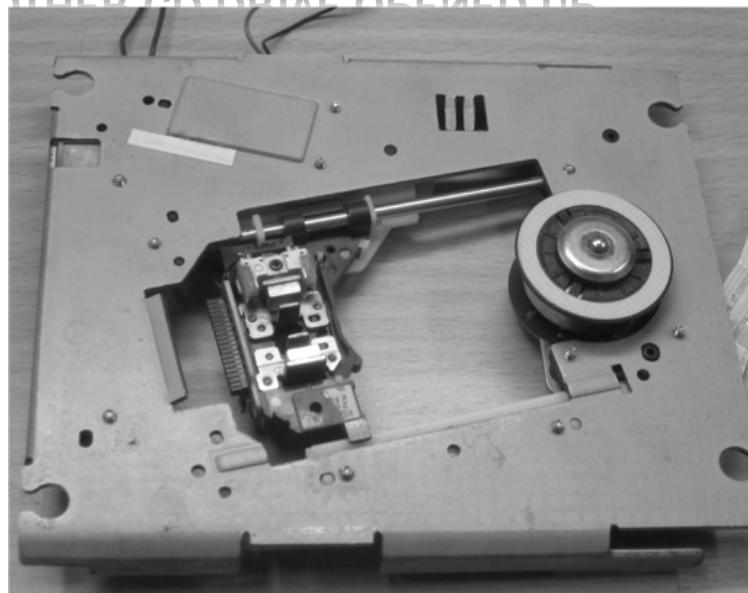
CDROM/WRITER DRIVE OPENED UP



8

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ANOTHER CD DRIVE OPENED UP

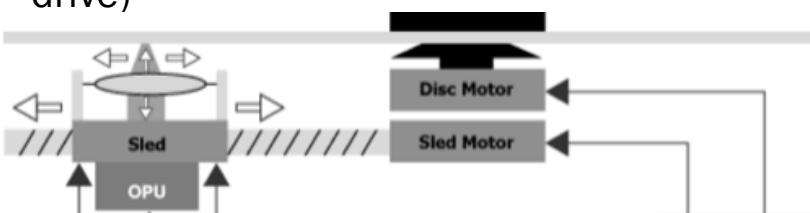


9

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VARIOUS SUBSYSTEMS

- ✗ Gross positioning servo – gross tracking
- ✗ Fine positioning (radial) servo – fine tracking
- ✗ Focussing servo
- ✗ CD handling system
- ✗ CD rotating servo system (based on PLL motor drive)

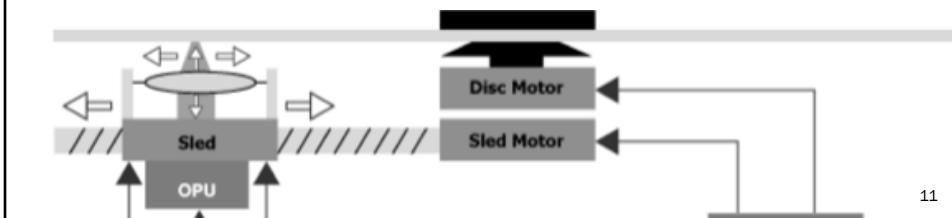


10

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VARIOUS SUBSYSTEMS

- ✗ Gross positioning servo – gross tracking
 - ✗ Fine positioning (radial) servo – fine tracking
- }
-
- ✗ Think for these two subsystems what are the specific elements of mechatronic system:
Sensor, Actuator, Controller??

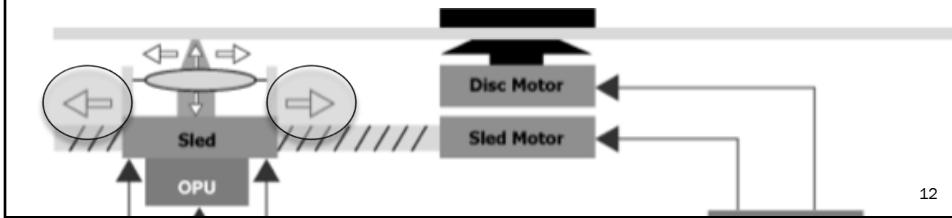


11

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VARIOUS SUBSYSTEMS

- Gross positioning servo – gross tracking*
- ✗ Sensor : Encoder or no sensor
 - ✗ Actuator: PMDC servomotor with gear transmission system OR stepper motor
- }



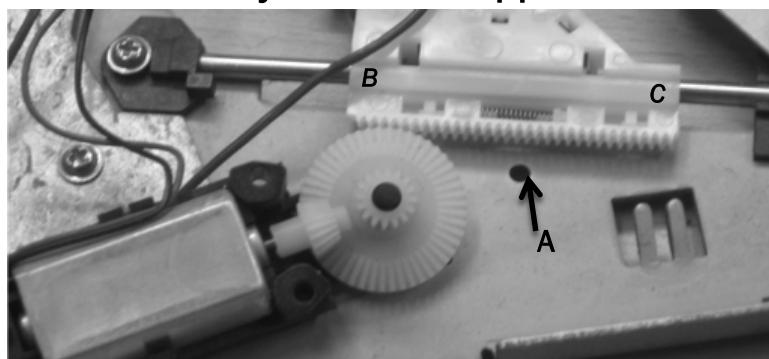
12

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VARIOUS SUBSYSTEMS

Gross positioning servo 1 – gross tracking

- ✗ Sensor : Encoder or no sensor
- ✗ Actuator: PMDC servomotor with gear transmission system OR stepper motor



13

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VARIOUS SUBSYSTEMS

Gross positioning servo 2 – gross tracking

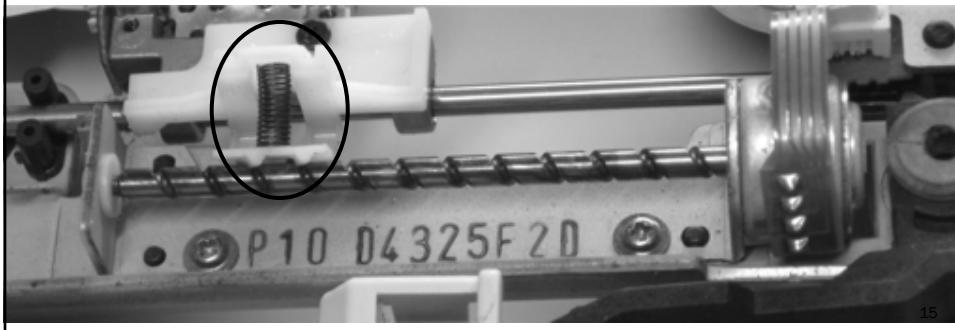
- ✗ Sensor : Encoder or no sensor
- ✗ Actuator: PMDC servomotor with gear transmission system OR stepper motor



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GROSS POSITIONING SERVO

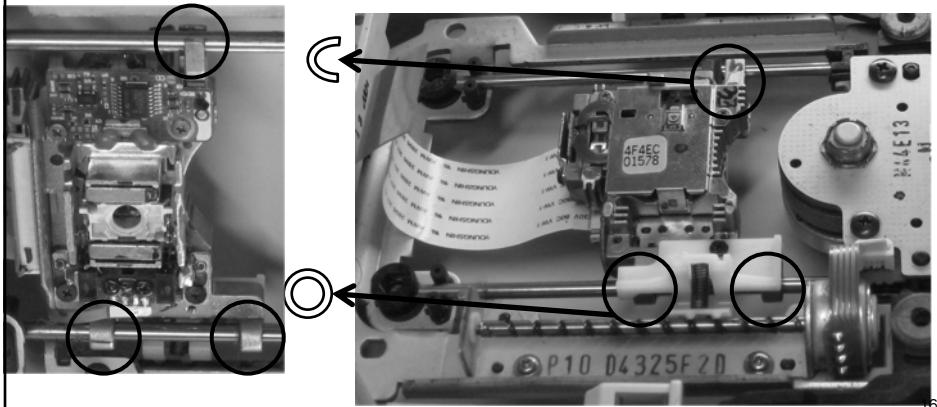
- ✖ Finer mechanical details to take care of ease in electronic / control domain
 - + Screw type drive: Why there is spring loading? How it works to prevent any backlash?



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GROSS POSITIONING SERVO

- ✖ Guide rail system: Notice how the head is guided on two rods

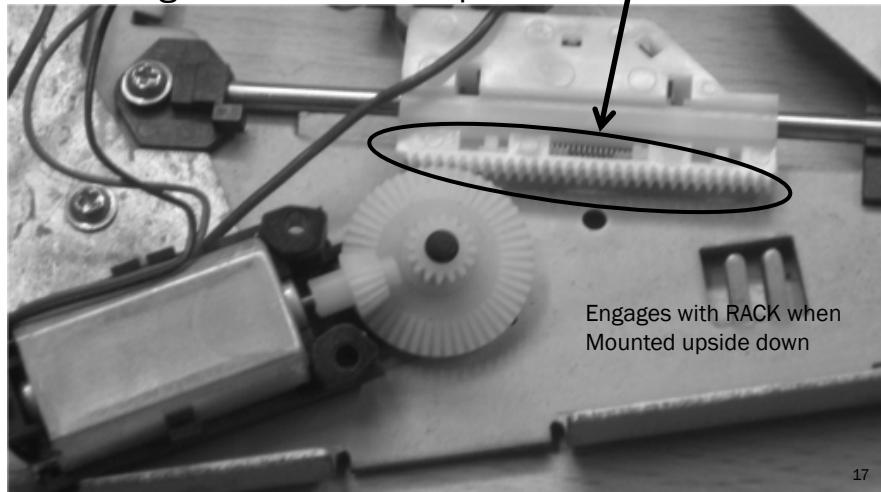


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GROSS POSITIONING SERVO

- ✖ Various mechanisms

- + Bevel gear with rack and pinion



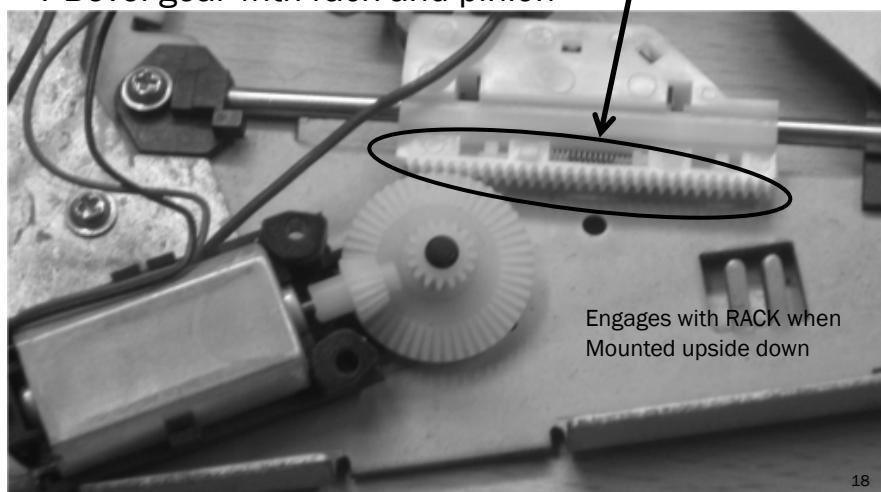
17

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GROSS POSITIONING SERVO

- ✖ Various mechanisms

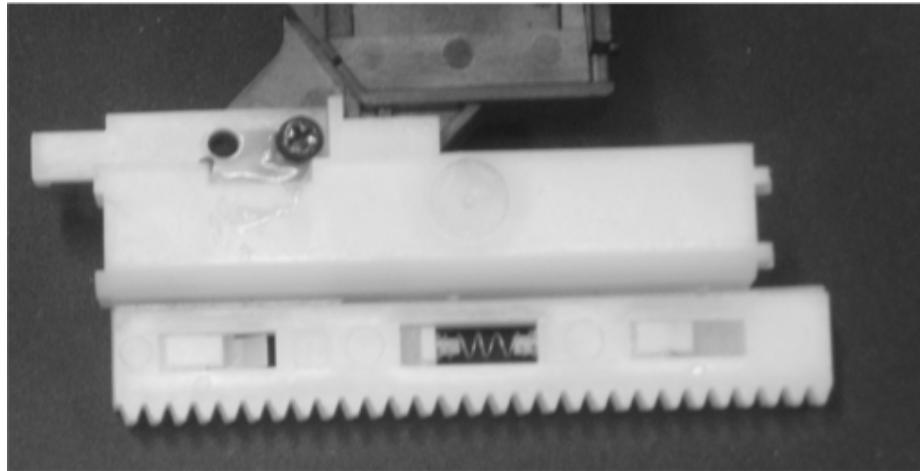
- + Bevel gear with rack and pinion



18

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~~SPRING LOADED RACK FOR ZERO BACKLASH~~



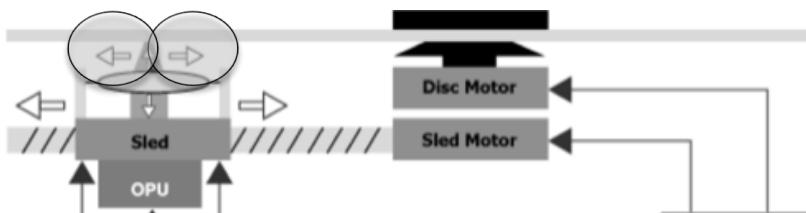
19

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~~VARIOUS SUBSYSTEMS~~

Fine positioning (radial) servo – fine tracking

- ✗ Sensor: Photodiode in an innovative way (we need submicron accuracy here)
- ✗ Actuator: Voice coil actuator in permanent magnet and compliant mechanism guiding system

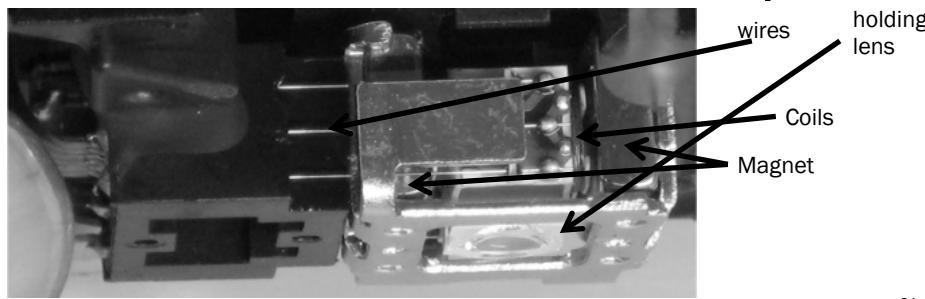


20

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FINE POSITIONING: FOCUSING AND TRACKING

- ✖ Compliant mechanism system to achieve 100 nm positioning accuracy
 - + Six (3 on each side) wire suspension system for lens focusing laser on CD surface

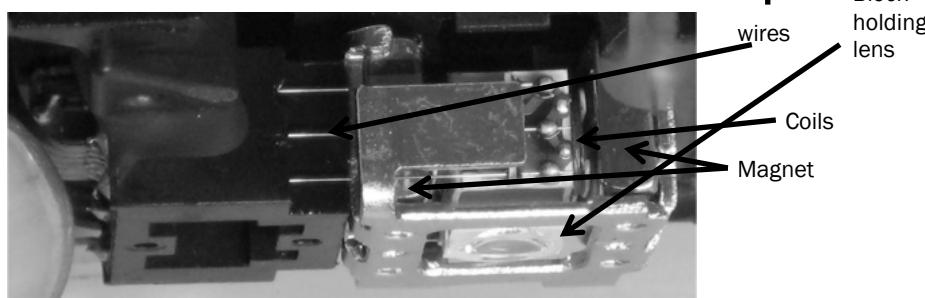


21

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FINE POSITIONING: FOCUSING AND TRACKING

- ✖ Flexure based mechanism system to achieve 100 nm positioning accuracy
 - + Six (3 on each side) wire suspension system for lens focusing laser on CD surface



22

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FINE POSITIONING: FOCUSING AND TRACKING

- ✖ Lens holding block in non deflected position: notice wires!!



23

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FINE POSITIONING: FOCUSING AND TRACKING

- ✖ Lens holding block in deflected position: notice wires!!

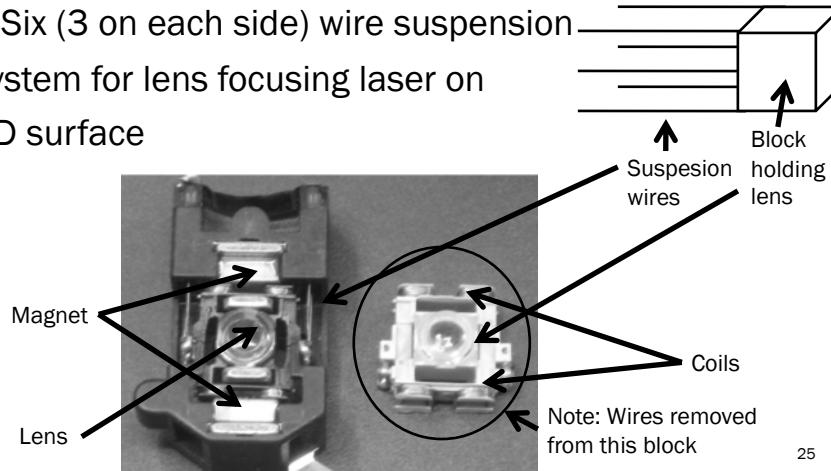


24

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Another example: opened system

FINE POSITIONING: FOCUSING AND TRACKING

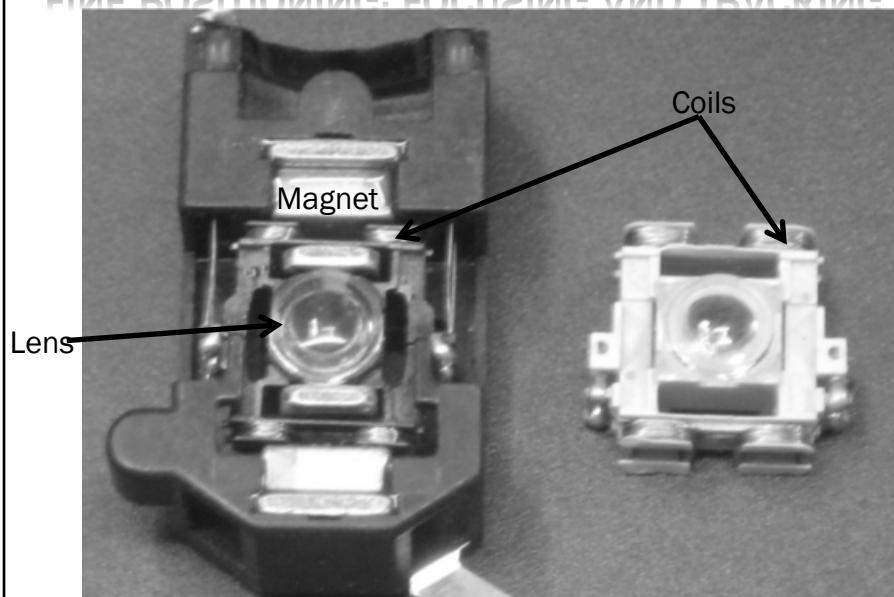
- ✖ Flexure based mechanism system to achieve 100 nm positioning accuracy
 - + Six (3 on each side) wire suspension system for lens focusing laser on CD surface



25

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Another example: opened system

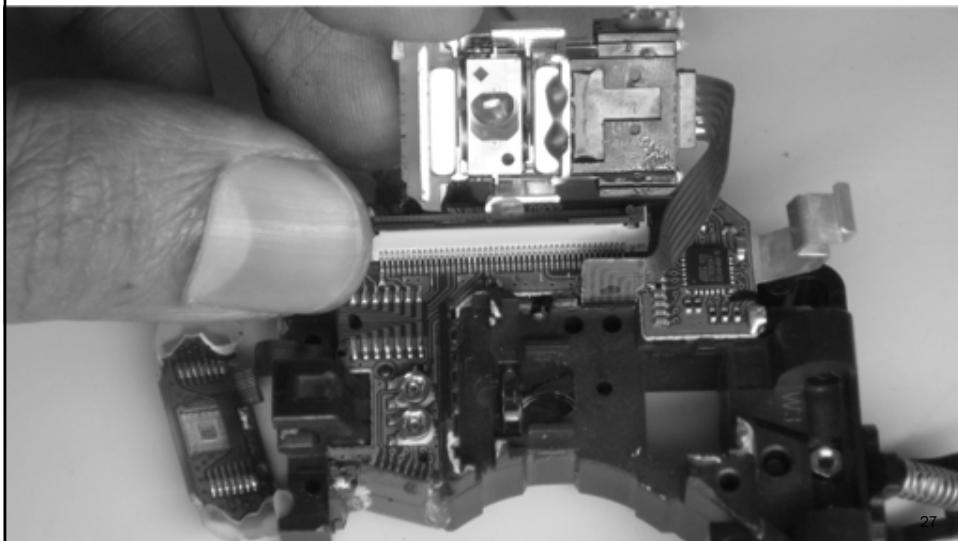
FINE POSITIONING: FOCUSING AND TRACKING



26

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FINE POSITIONING: FOCUSING AND TRACKING



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SENSING MECHANISM

- ✗ 3 beam method with quadrature photodiode for sensing if the head is precisely on track
- ✗ Optomechatronics used for the same

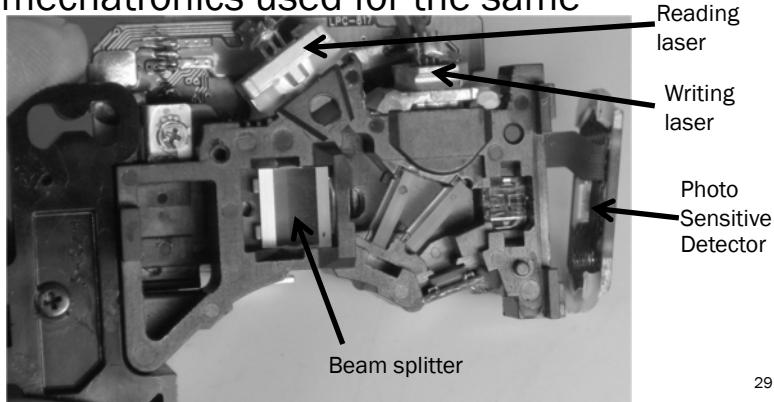


28

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SENSING MECHANISM

- ✗ 3 beam method with quadrature photodiode for sensing if the head is precisely on track
- ✗ Optomechatronics used for the same



29

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SENSING MECHANISM



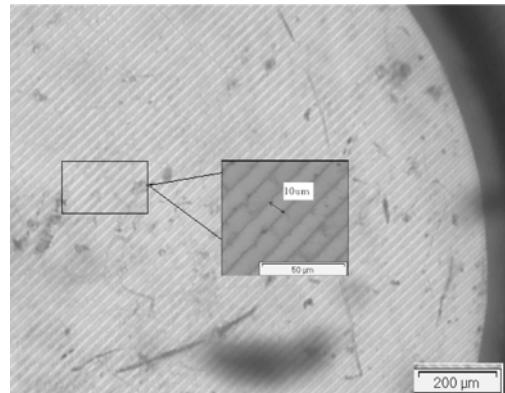
30

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HOW TO PRODUCE 3 BEAMS

→ Diffraction grating

- ✓ Groove spacing $10\mu\text{m}$
- ✓ Groove width $1\mu\text{m}$
- ✓ 128 number of grooves

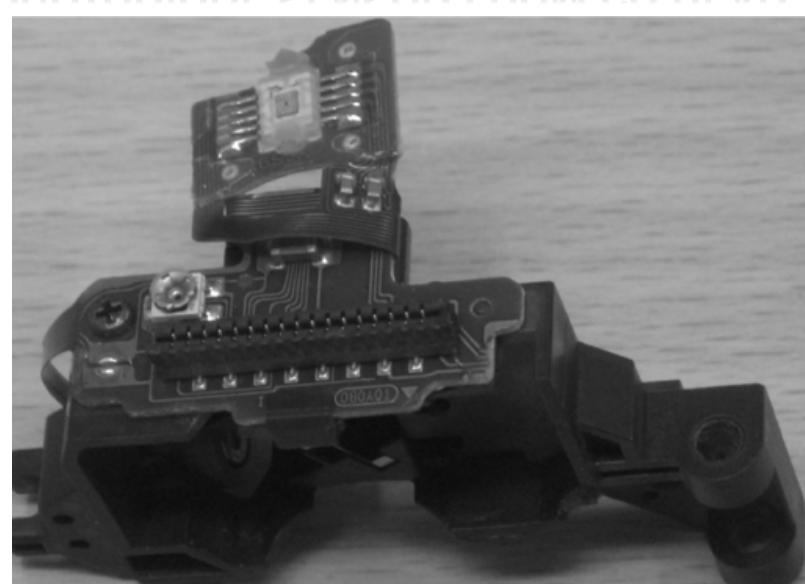


Microscopic image of Diffraction grating

31

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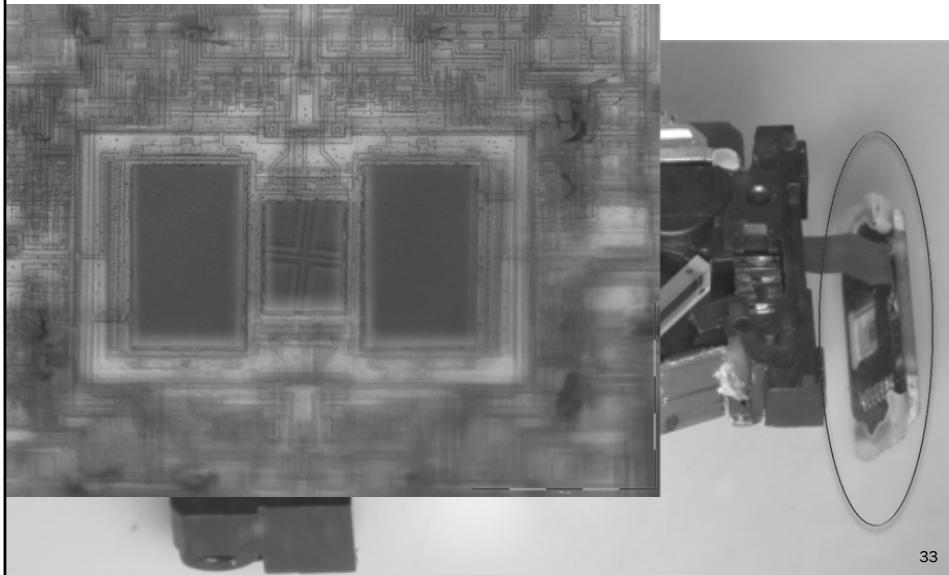
PHOTODIODE SENSOR FROM CD HEAD



32

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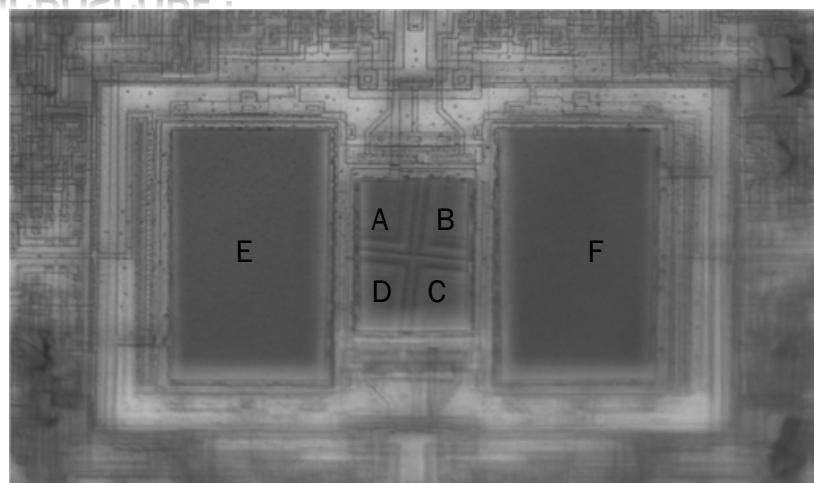
PHOTO DIODES ABCD EF



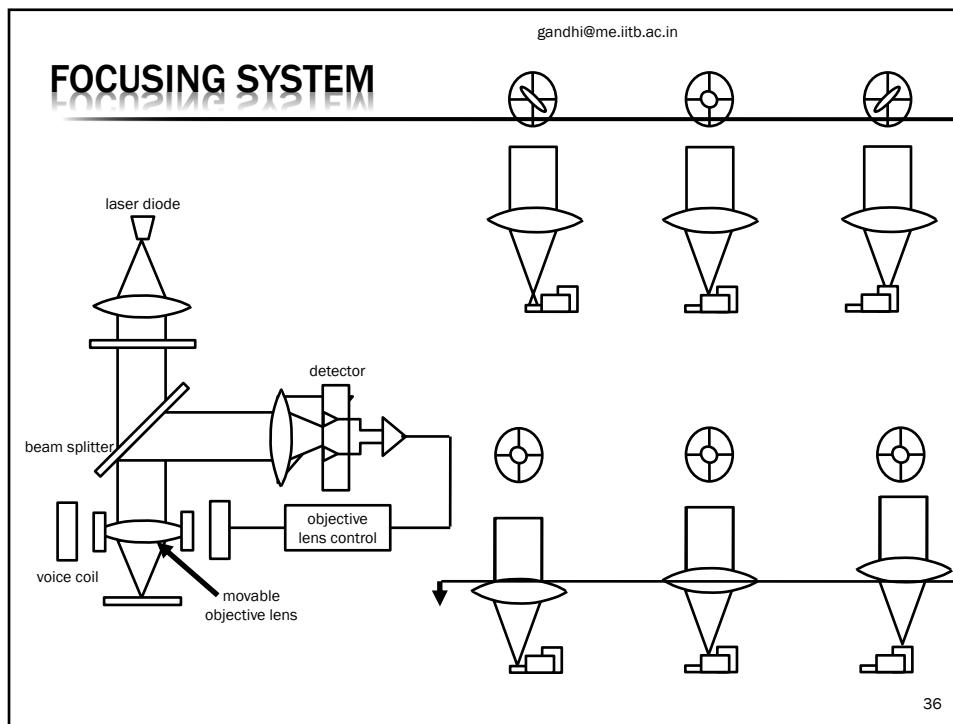
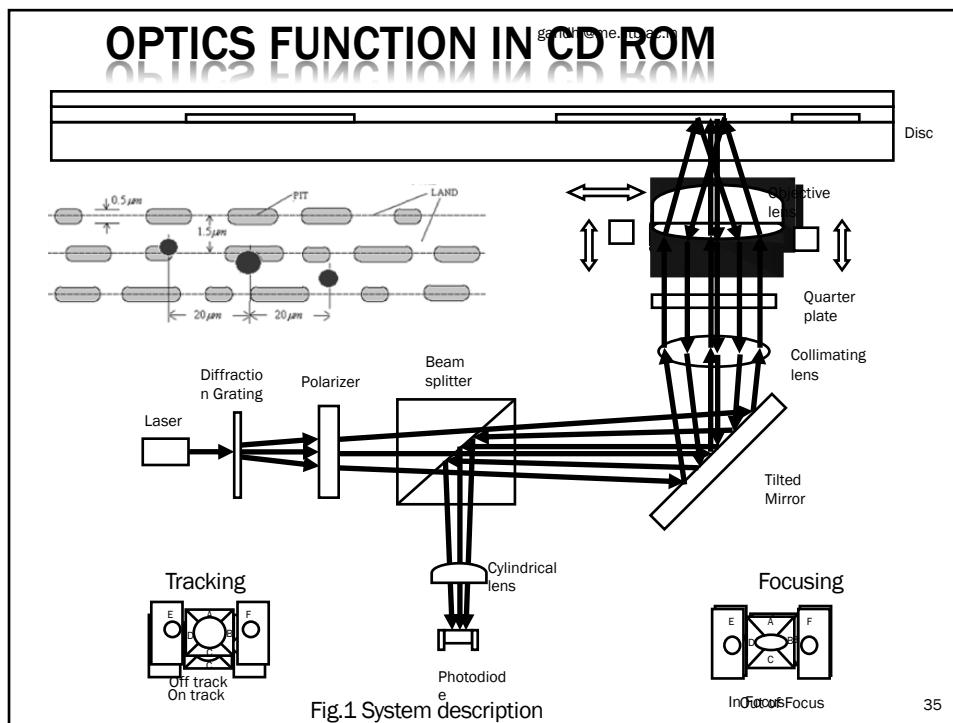
33

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PHOTODIODE SENSOR HOW IT LOOKS UNDER MICROSCOPE :



34



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CONTROL

- ✖ Typical control implementation would involve
 - + Reading sensors
 - + Computing control
 - + Implementing control input on actuator
- ✖ First gross positioning would be done and then the fine positioning
- ✖ Control strategies would be planned and computed in microprocessor

37

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SUMMARY LESSONS

- ✖ When we need lower accuracy (upto 0.05mm) in positioning go for rigid mechanical system with gears or mechanisms
- ✖ When we need higher accuracy (lower than 20 microns) employ compliant mechanism based systems (in some cases piezoactuators if the range is small)
- ✖ For larger range combination of above two
- ✖ One needs to think in mechanical and systems domain together to think “mechatronically”
- ✖ There can be always smarter and innovative ways of design do not constrain yourself

38

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SUMMARY LESSONS

- ✖ Components (sensors, actuator, mechanical plant) in CD ROM and other such commercially available mechatronics systems can be used to built high accuracy positioning systems for other application or student projects or similar ideas can be used at larger scale
- ✖ Example
 - + Mechanical probing system for MEMS
 - + Biological cell handling / probing system
 - + A linear guide mechatronic system
 - + A system for demonstration of mechatronics fundamentals to students and so on

39

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THANK YOU

40

