Course material

Course:

Micro and Nanofabrication (MEMS)

Video:

4.1 Lithography 1, General concepts, I Introduction to lithography

Concepts (extracted from automatically generated subtitles):

Resist patterns. Electron beam lithography. Lithography variations. Uv lithography. Majority of the cases. Lithography masks. Thin layer of radiation. Use of a uv light source. Fundamental process. Lithography. Lithography exposure step. Uv light. Various regions. Surface of a wafer substrate. Chemical reaction.

to video sequence search
(within Micro and Nanofabrication (MEMS).)

to video

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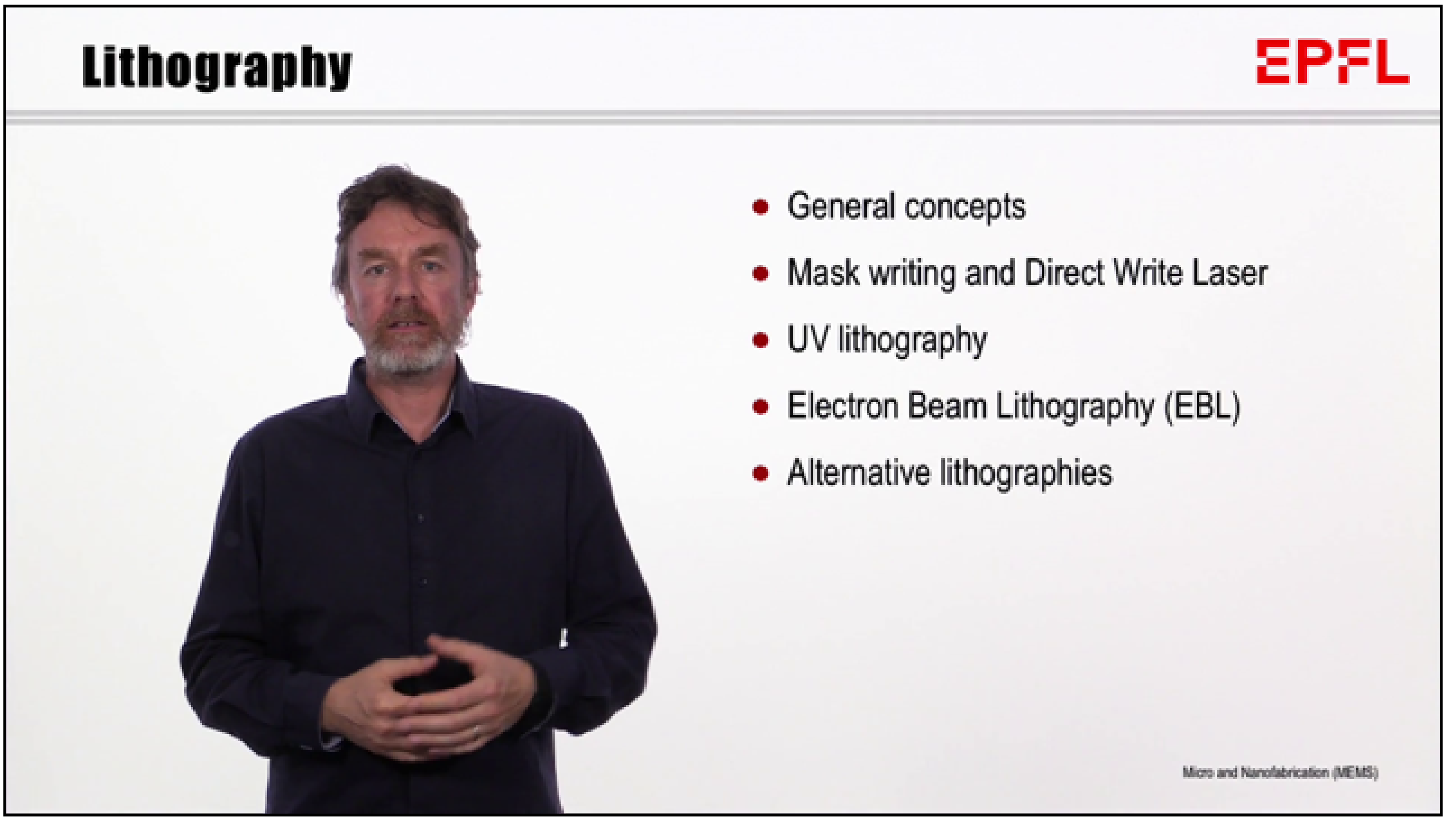
notes

summary

0m 0s

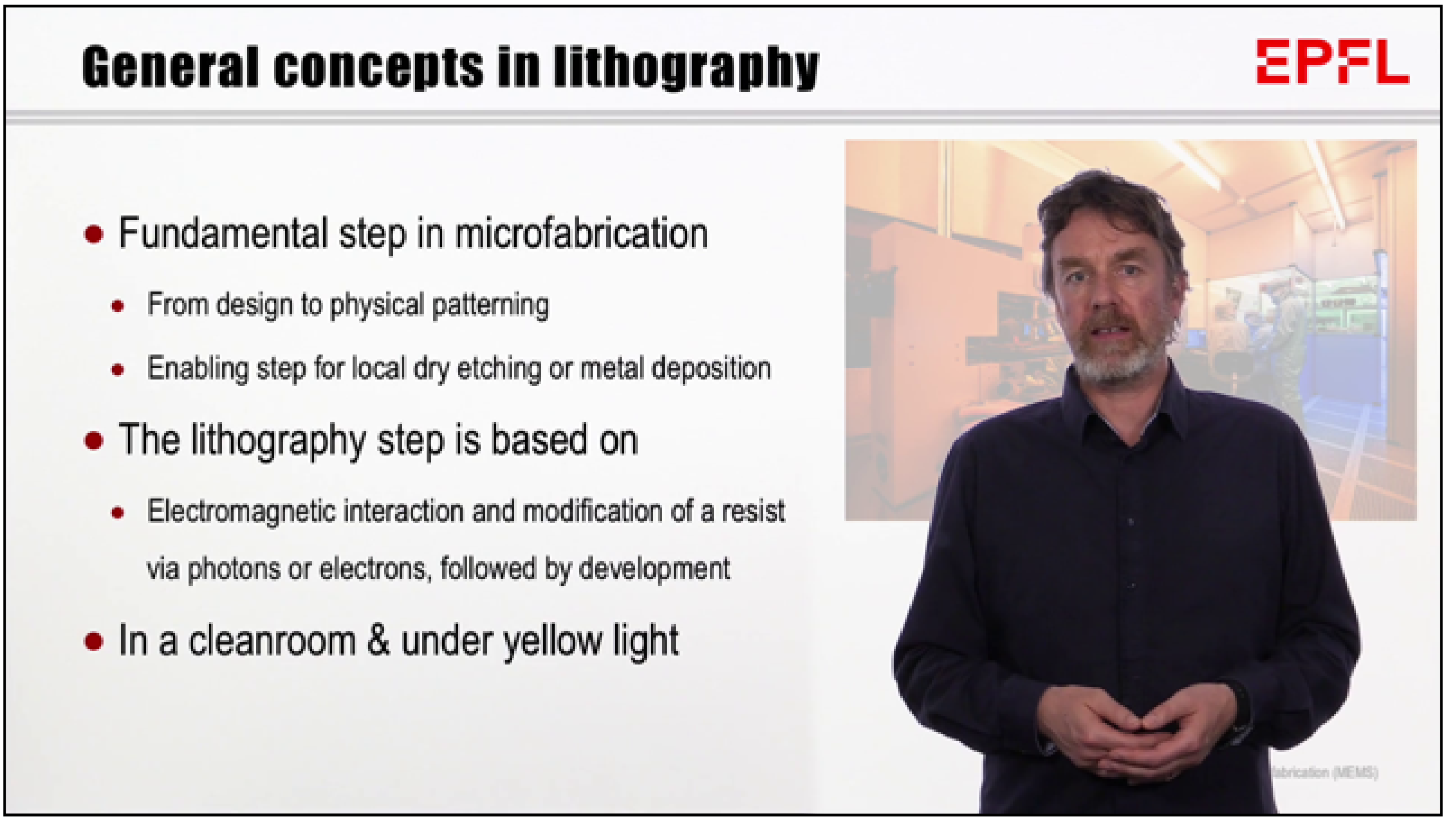


As there are several possibilities to perform lithography,

notes

summary

0m 1s



I will start by providing some definitions and by explaining some general concepts that are recurring for all the lithography variations. Then I will dive into details how one fabricates the lithography masks using a direct write laser tool. This will be followed by a closer look into UV lithography and electron beam lithography which are to date the two main categories of lithography. I will then conclude by presenting new emerging and alternative lithographies which are not yet part of the main stream applications, but that offer interesting opportunities for niche applications. Lithography is the fundamental process of transferring geometric shape from a design to a thin layer of radiation sensitive material called resist, which is covering the surface of a wafer substrate. These shapes or patterns define the various regions in an integrated circuit, such as the implantation regions, the contact windows, the metallic wiring etc. The resist patterns made by lithography are not permanent but only temporary replicas of circuit or MEMs features. To produce the final features in the material of interest, these resist patterns must be transferred once more into the underlying layers, for instance by an etching process which selectively removes unmasked portions of a layer. The pattern transfer techniques are described in more details in the lesson on wet and dry etching.

notes

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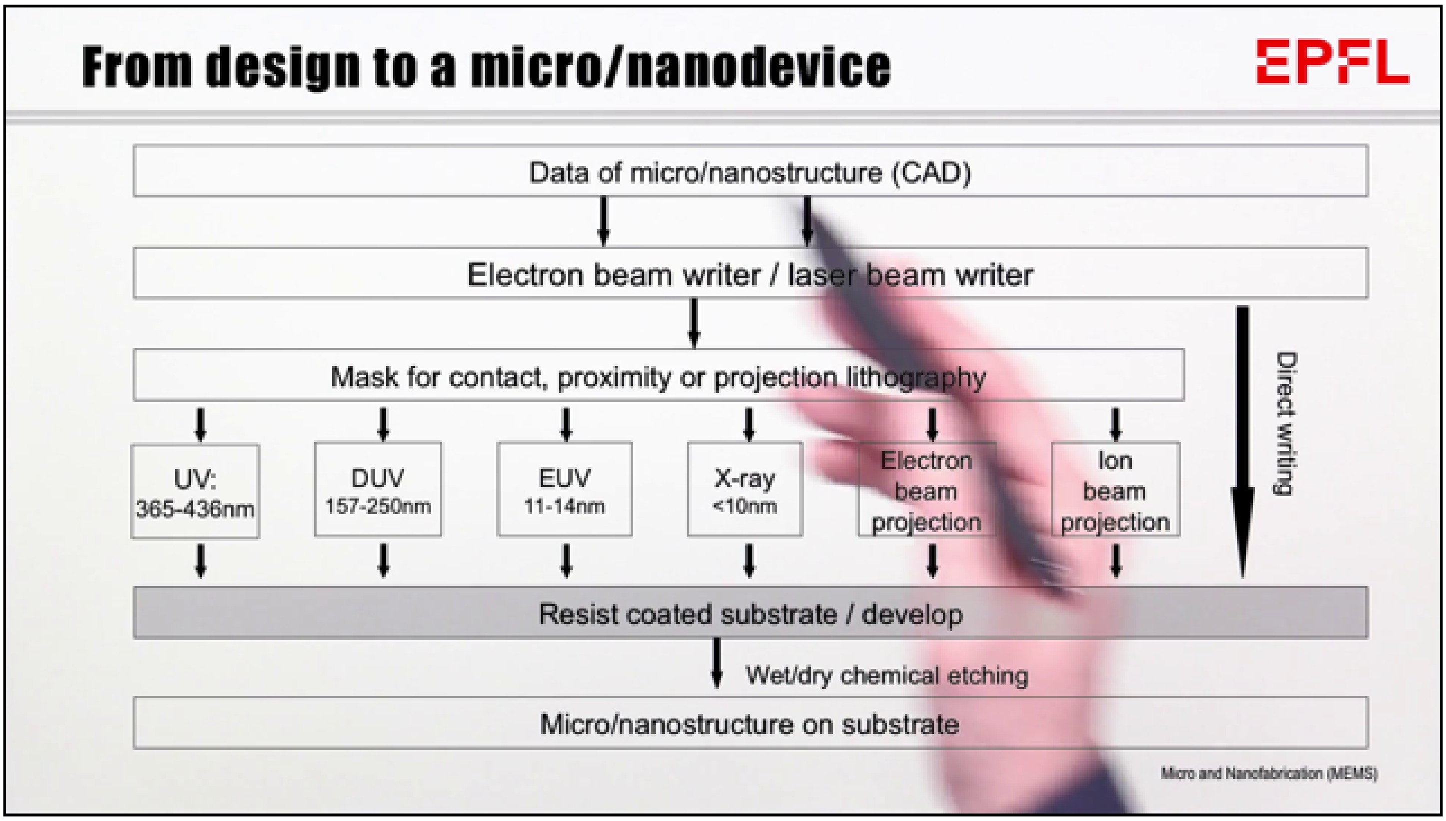

The lithography exposure step itself can be done by various sources of electromagnetic radiation, either by using photons or electrons. All lithography processes must be performed in an ultra clean environment to avoid that any dust particle in the air can settle on the wafers or lithography masks and can cause defects in the device. Lithography is also carried out in yellow light. Indeed, the photo resist is sensitive to light with shorter wavelengths. UV light is therefore filtered out from lithography areas in a clean room. More on clean room specific features are given in the corresponding lesson. This slide provides an overview of possible parts from a design file or a CAD file, on a computer to define a micro or nano structure or circuit on a wafer.

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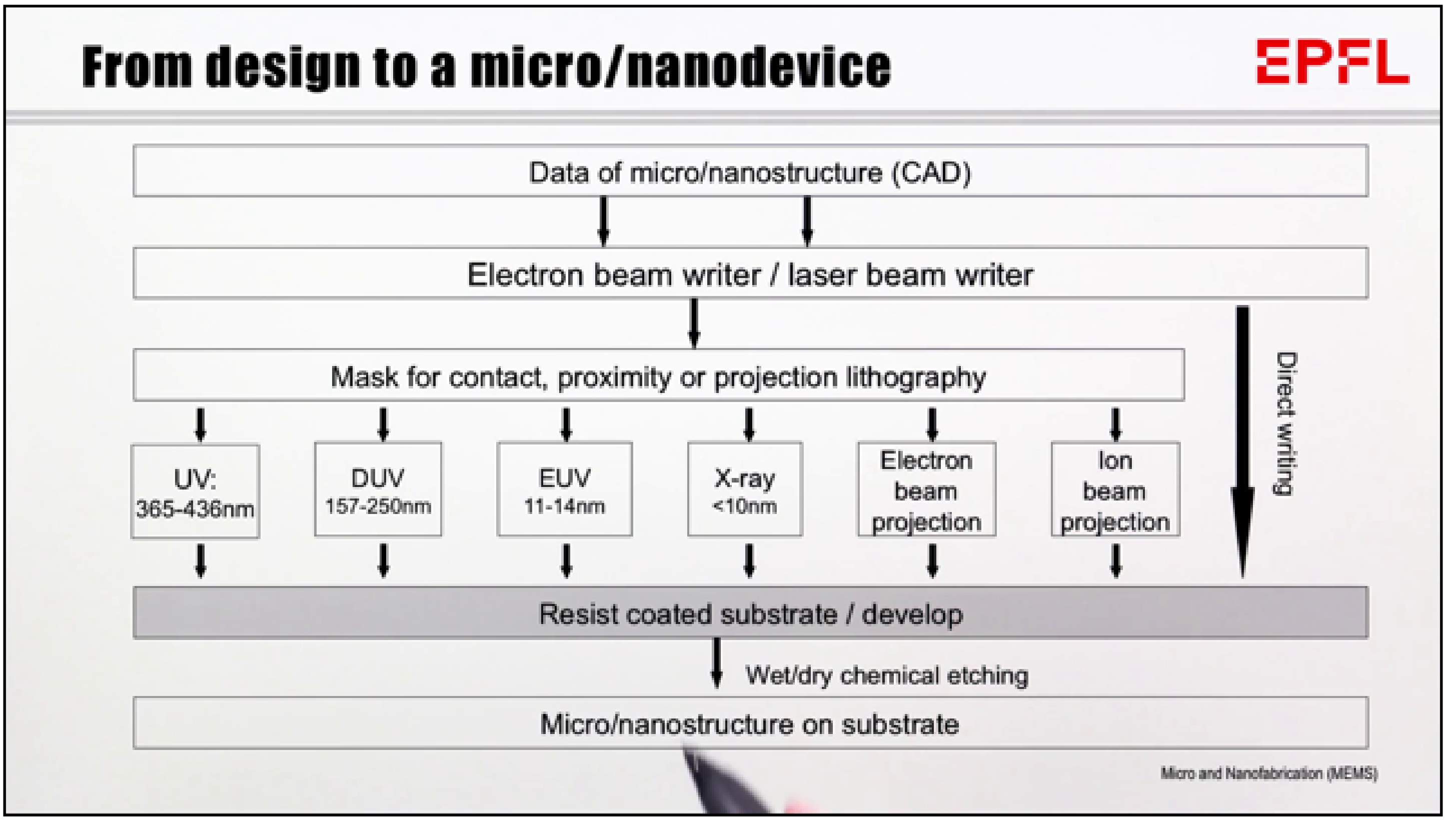
1m 37s

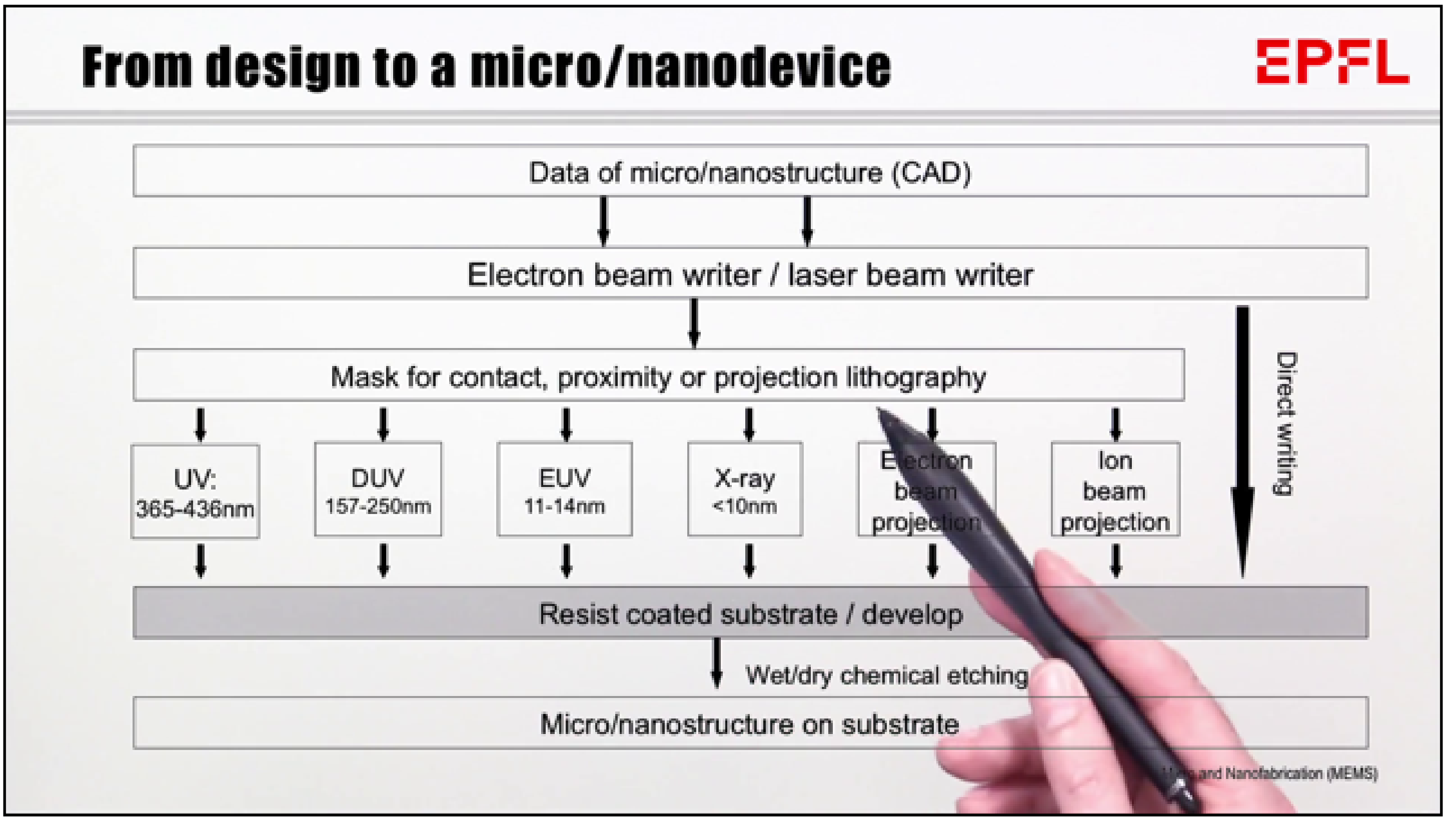


Here is the start of the data on the CAD file, on a computer.

notes

summary

2m 25s



And at the end, we want to have the micro or nano structures on a substrate. From the CAD file, we can steer by computer control, the write head of a beam writer that uses either focused laser or electrons. This is the first conversion from a virtual computer design feature into a physical reality. In the majority of the cases

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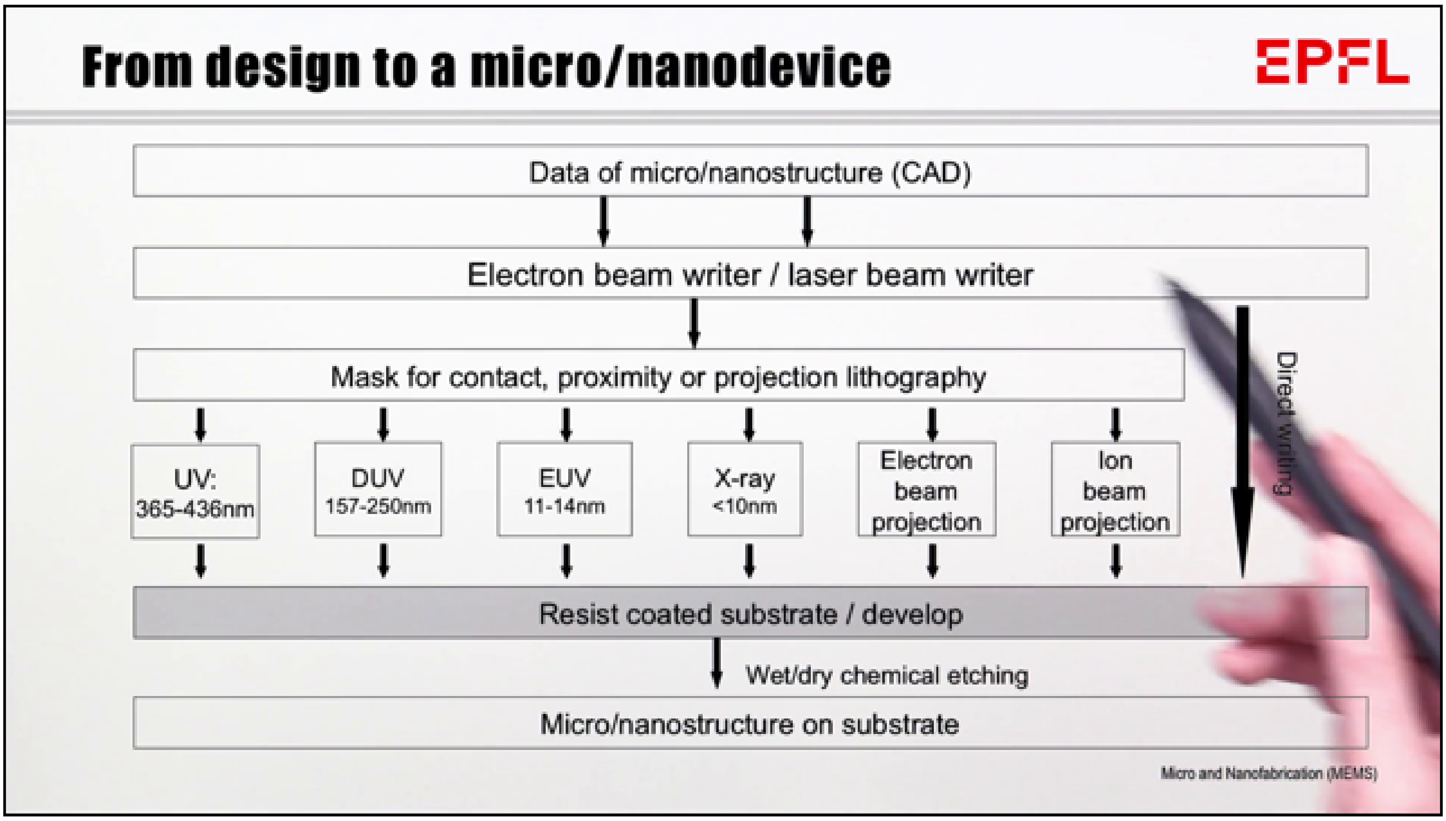
summary

2m 29s

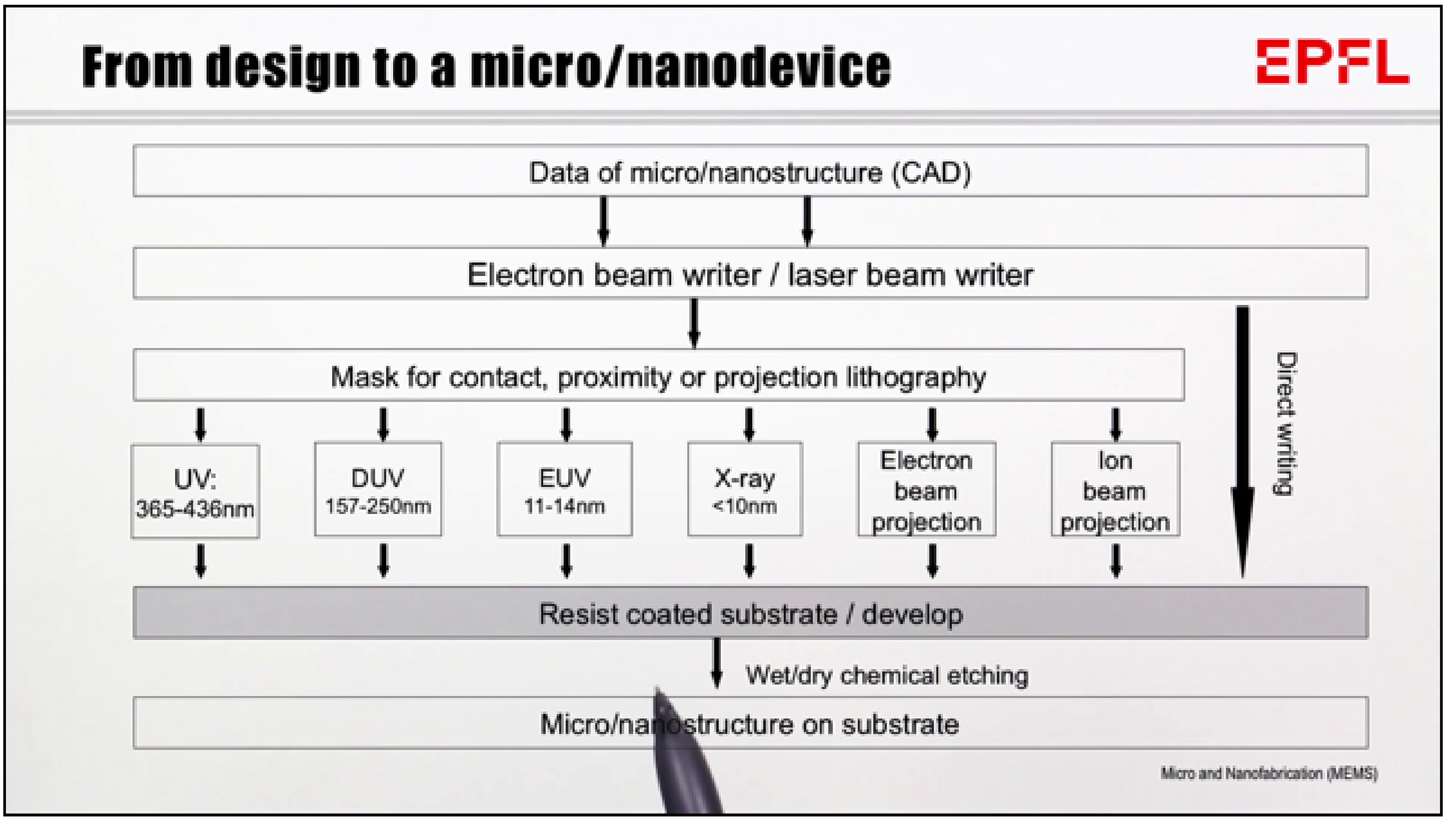


the beam writer is used to fabricate masks for lithography. This is because the writing can take a lot of time. Only in cases of R&D; when only few devices are needed.

notes

summary

2m 55s



One considers the direct writing of the final structure. Depending on the radiation source, one speaks about UV, deep UV, extreme UV, x-ray, electron beam projection, or ion beam projection masks, all with their own specificities.

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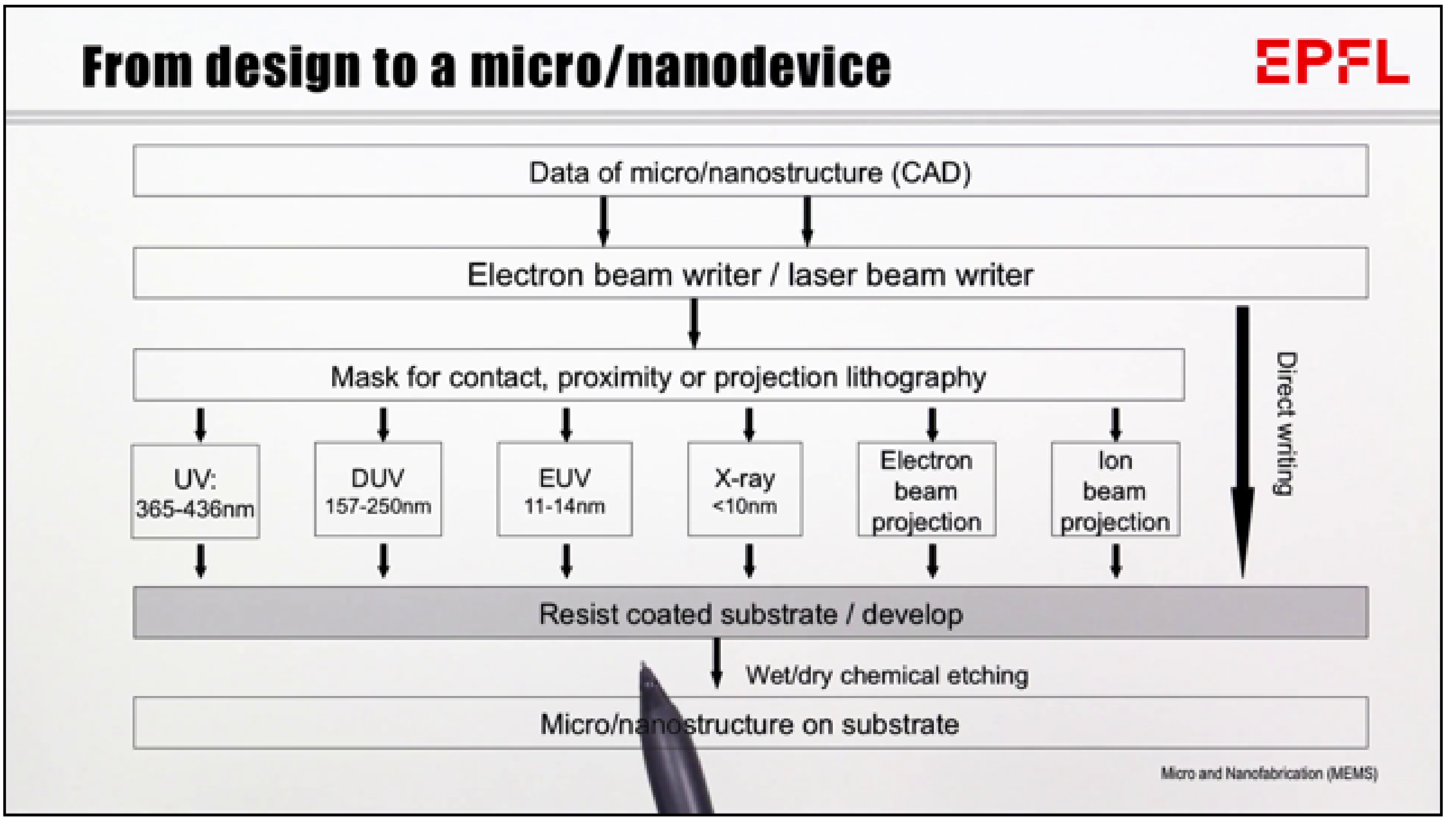
3m 4s

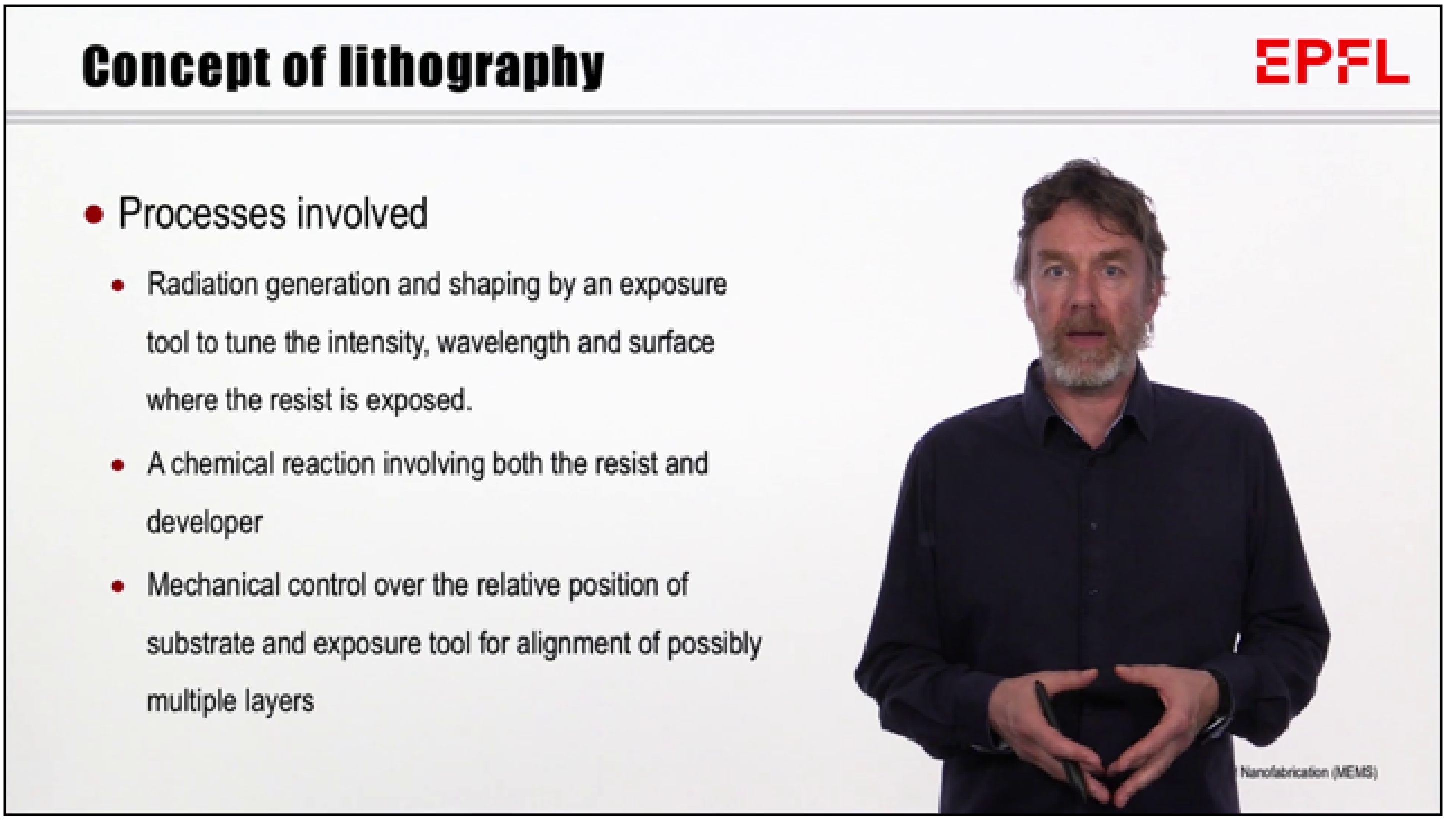


In each case, the radiation impinges locally

notes

summary

3m 25s



onto a resist coated substrate and modifies the resist which can then be developed. The resist subsequently serves as a mask for pattern transfer by etching to complete the micro or nano fabrication step. So once again to summarize, the processes involved in lithography firstly include the generation of a radiation that needs to be tuned and precisely shaped to impinge on the sensitive resist where needed. Second, it involves a chemical reaction between the resist radiation, and then the resist and the developer. Last but not least, it requires a very precise mechanical tool for the positioning of the mask or the beam on the resist coated substrate,

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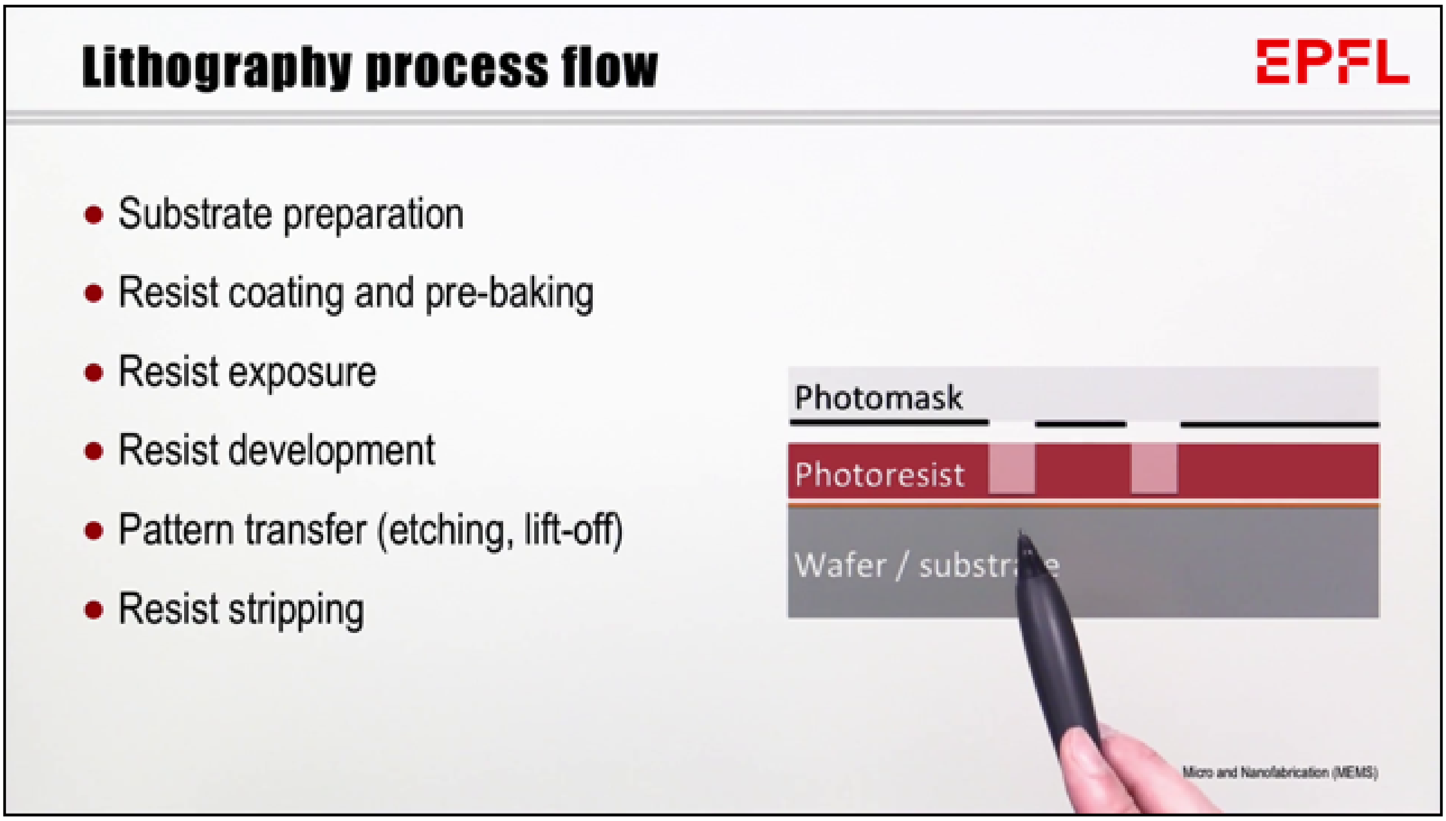
summary

3m 27s



in particular for the patterning of alignment and multi-layer features. Each lithography follows a well defined series of process steps, called process flow. It may vary according to the lithography used and the materials involved. But a typical generic example is shown here, where we go step by step through it. First the substrate - it can be a silicon wafer or glass plate - is cleaned and prepared and eventually coated with a thin film of material that needs to be patterned. Second, the photo resist is being coated on the substrate to form a layer of it with a well controlled thickness in the order of a micrometer, but this can vary a lot. And most importantly, with a very uniform thickness over the entire substrate surface. Some pre-baking is done to remove excess solvent and to dry the resist. Then comes the essential step, which is the resist exposure. This step can be done either by photons or electrons. In this example shown here, I show the use of a UV light source and expose the resist through a photomask that contains transparent (here), and opaque regions. Only under the transparent portions of the mask we will expose the resist. The other method would be using electrons that can be scanned over the surface, and thereby writing the pattern - this will be shown in details later. In both cases, the goal is to chemically modify the resist under the radiation so that it becomes either polymerized by creating new chemical bonds, or by breaking existing chemical bonds. The choice to use either optical UV lithography or electron beam is driven by the quest for resolution and throughput. The step after the exposure is resist development, shown here, which is a chemical bath that dissolves the part of the resist that has not been polymerized or whose bonds have been weakened by the exposure. Then the resist

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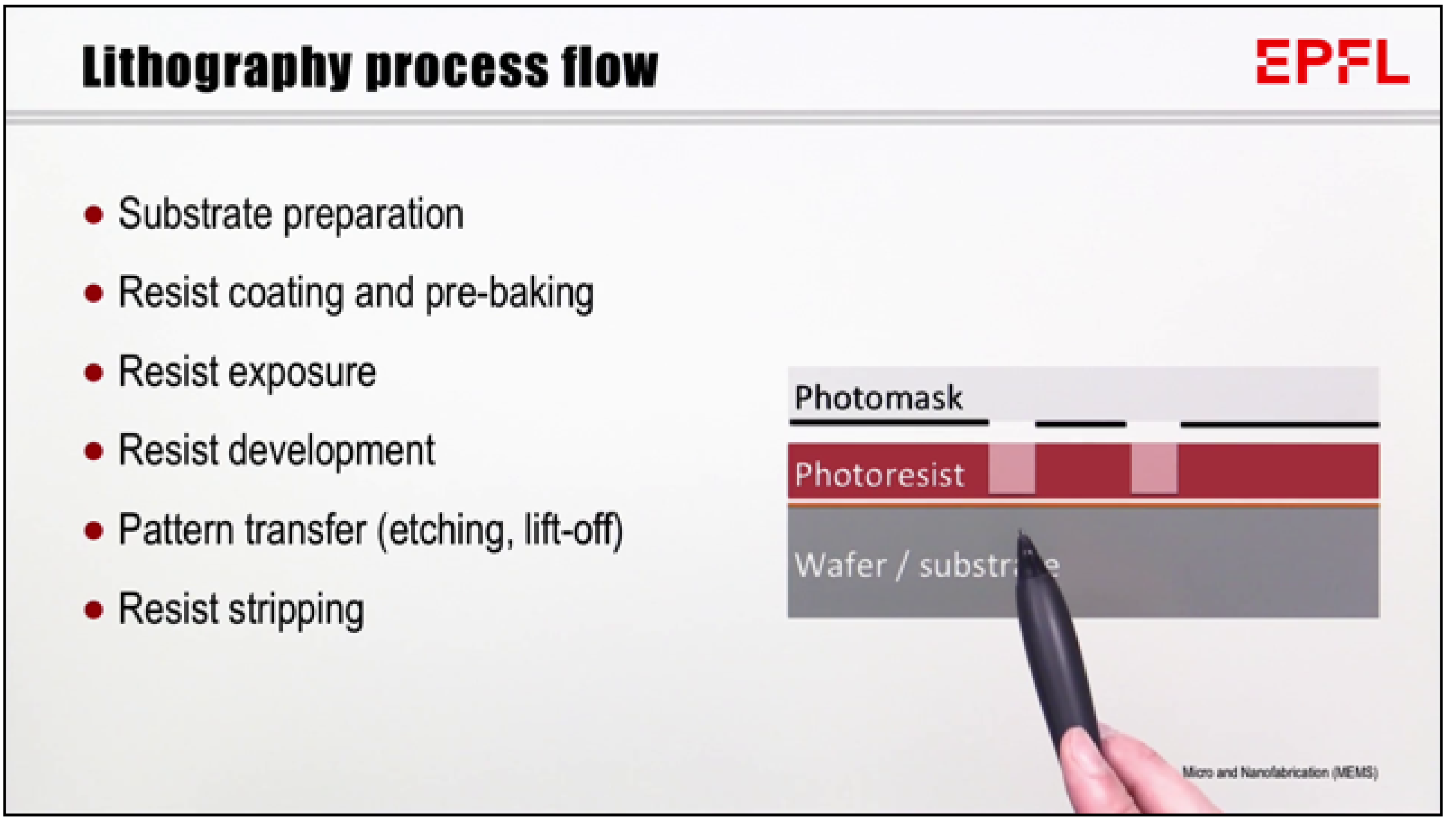
4m 13s



pattern is transferred into the layer of interest by etching or by lift-off. These steps will be explained elsewhere in this course. At the end, the resist is not used anymore and can be removed by a so-called stripping process in solvent and cleaning acids. And the target device pattern is now completed.

notes

summary