

# Design & Fabrication

Dr.-Ing. **Florian Wolling** (Lecture), M.Sc. **Ambika Shahu** (Exercises),  
**Thomas Mantschko** (Tutor), Prof. Florian Michahelles

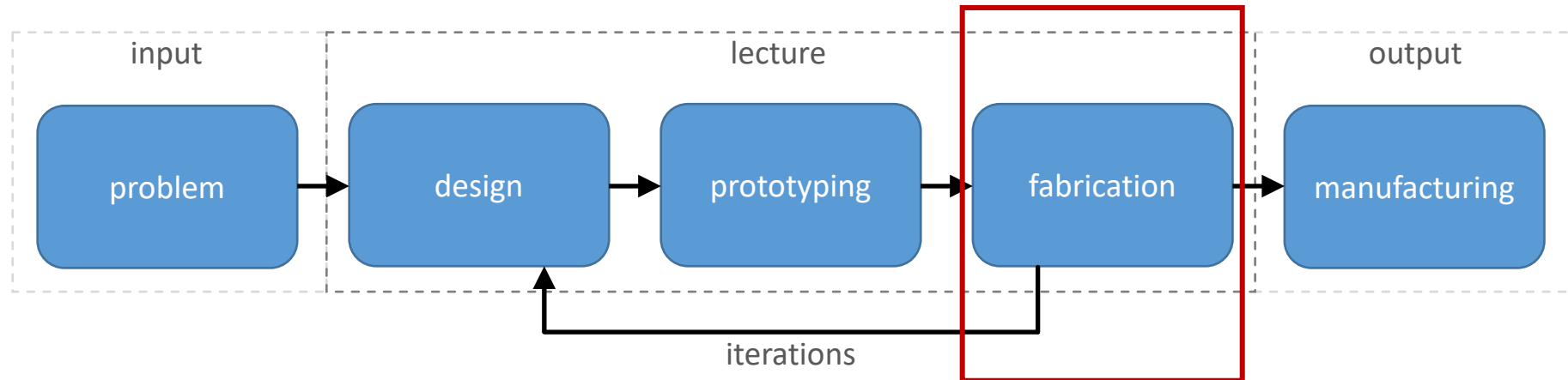
Technische Universität Wien

Artifact-Based Computing & User Research (<http://media.tuwien.ac.at>)  
[florian.wolling@tuwien.ac.at](mailto:florian.wolling@tuwien.ac.at), [ambika.shahu@tuwien.ac.at](mailto:ambika.shahu@tuwien.ac.at)



# From Design to Fabrication

## Recapitulation



## Lecture 6

# Forming and Subtractive Fabrication Technologies

How would you fabricate a hollow chocolate figure?



# Forming and Subtractive Fabrication Technologies

## Motivation



# Forming and Subtractive Fabrication Technologies

## Fabrication Technologies

### Fabrication Technologies

- › Production of geometric bodies
- › Specific dimensions
- › Manual manufacturing
- › Computer Numerical Control (**CNC**)

# Forming and Subtractive Fabrication Technologies

## Fabrication Technologies

### 1. Preforming

- › Master forming, shaping
- › Creating cohesion
- › Manufacturing of a workpiece
- › **Casting** (Gießen) with molten material
- › **Sintering** of powders or granulates
- › **Molding** (Pressformen) of pastes, putties (Knete/Kitt), wax, loam (Lehm), or clay (Ton)
- › **3D printing**, rapid prototyping

# Forming and Subtractive Fabrication Technologies

## Fabrication Technologies

## 2. Forming

- › Changing shape without removing material
- › Maintaining cohesion
- › Deforming a workpiece **without adding or removing material** (mass conservation)
- › **Rolling** (Walzen)
- › **Bending** (Biegen)
- › Drop forging (Gesens Schmieden)
- › **Extrusion** (Pressen)
- › **Deep drawing** (Tiefziehen)



# Forming and Subtractive Fabrication Technologies

## Fabrication Technologies

### 3. Cutting

- › Changing shape by cutting or removing material
- › Reducing cohesion
- › Machining with a **defined cutting edge**:  
sawing, planing (Hobeln), milling, drilling, ...
- › Machining with a **geometrically undefined edge**:  
grinding (Schleifen), honing (Honen), lapping (Läppen), blasting (Strahlen), brushing (Bürsten), ...
- › Shear cutting, **punching** (Stanzen)
- › Flame cutting (Brennschneiden)
- › Spark erosion (Funkenerodieren)
- › Dismantling for disassembly

# Forming and Subtractive Fabrication Technologies

## Fabrication Technologies

### 4. Joining

- › Joining of several workpieces
- › Chemical and physical joints:
  - › Welding (Schweißen)
  - › Soldering (Löten)
  - › Gluing (Kleben)
- › Mechanical joints:
  - › Riveting (Nieten)
  - › Screwing (Schrauben)
  - › Assembling (Zusammensetzen)

# Forming and Subtractive Fabrication Technologies

## Fabrication Technologies

### 5. Coating

- › Application of thin layers
- › Adhering a **thin layer** of shapeless material to a workpiece
- › **Painting, varnishing** (Sprühlackieren)
- › Electroplating (Galvanisieren)
- › **Hot-dip galvanizing** (Feuerverzinken)
- › Powder coating (Pulverbeschichten)
- › Rubberizing (Gummieren)

# Forming and Subtractive Fabrication Technologies

## Fabrication Technologies

### 6. Changing Material Properties

- › Changing characteristic properties, e.g. the crystalline structures, grain boundaries
- › **Heat treatment:**
  - › Baking and glazing of ceramics
  - › Curing and vulcanizing of plastics
  - › Hardening (Härten) and annealing (Weichglühen) of metals
- › UV light exposure
- › Chemical treatment

# Forming and Subtractive Fabrication Technologies

## Fabrication Technologies

## Fabrication Technologies

1. Preforming
2. Forming
3. Cutting
4. Joining
5. Coating
6. Changing Material Properties

# Forming and Subtractive Fabrication Technologies

## Preforming

# Preforming

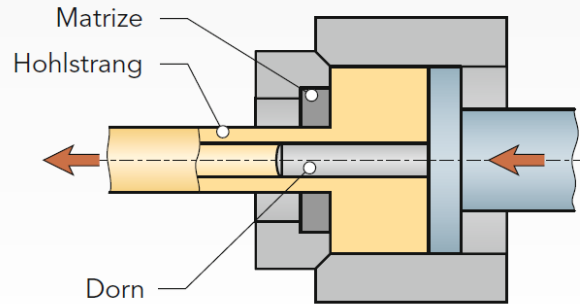
# Forming and Subtractive Fabrication Technologies

## Preforming

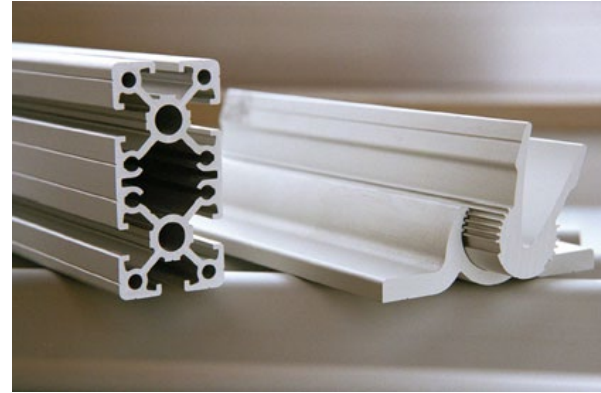
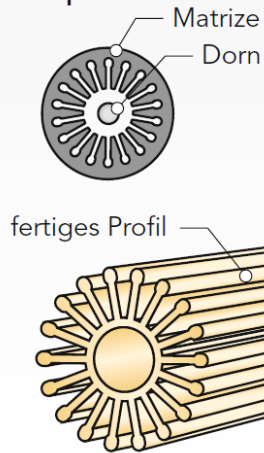
## Extrusion (Strangpressen)

### Prinzip des Strangpressens

#### Hohlstrangpressen



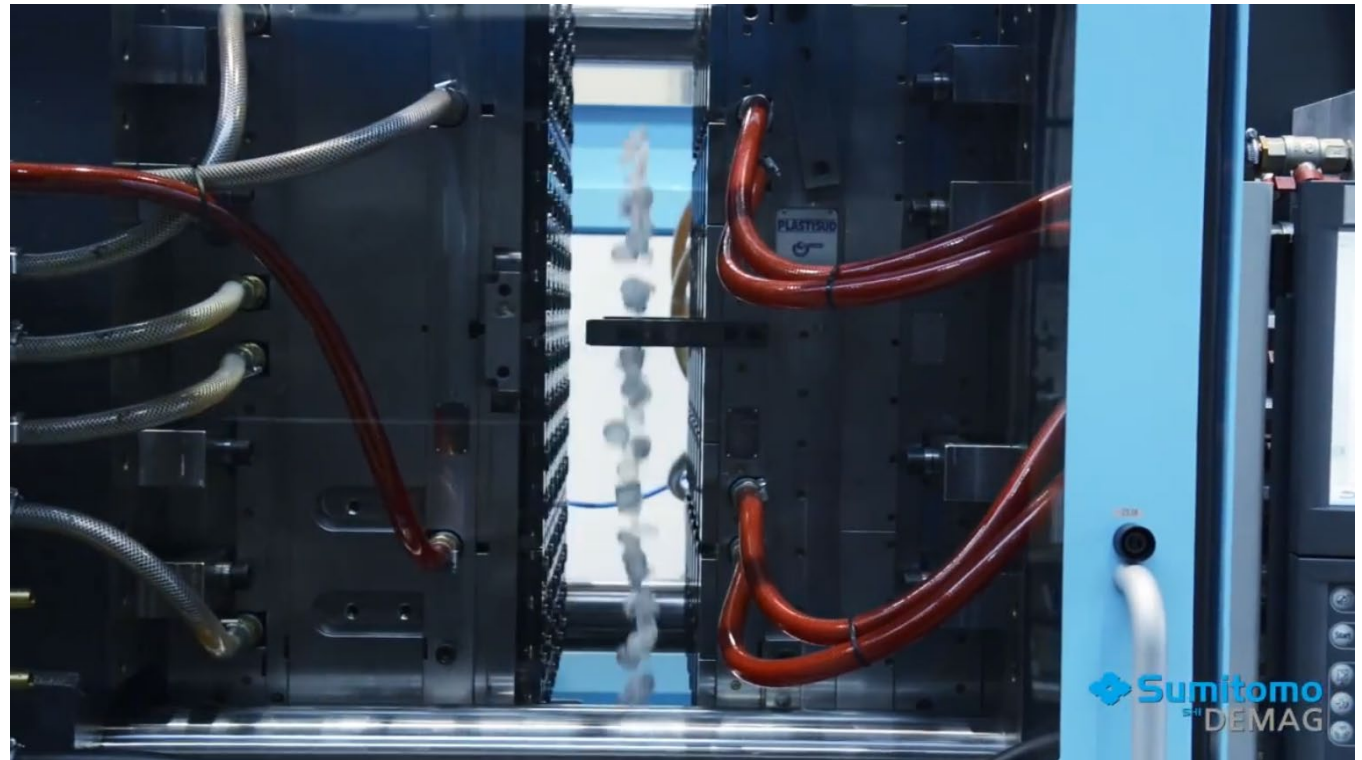
#### Beispiel



# Forming and Subtractive Fabrication Technologies

Preforming

## Injection Molding

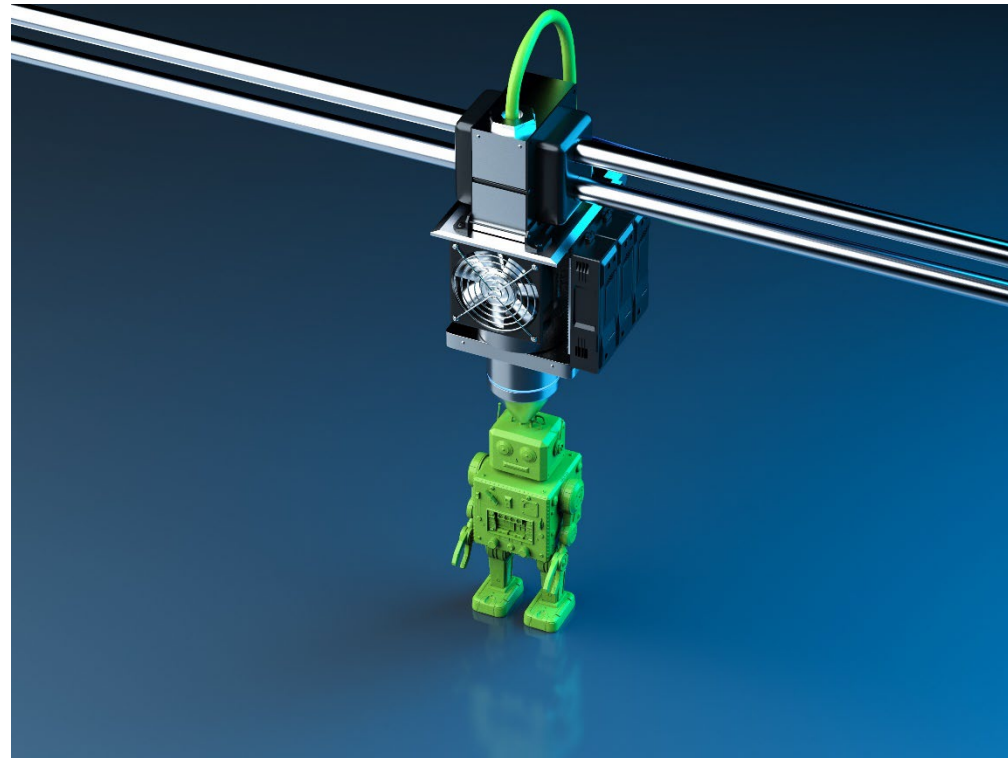




# Forming and Subtractive Fabrication Technologies

Preforming

## 3D Printing



Lecture on its own – next week!

# Forming and Subtractive Fabrication Technologies

## Forming

# Forming

# Forming and Subtractive Fabrication Technologies

## Forming

### Wire Straightening (Drahtrichten)



# Forming and Subtractive Fabrication Technologies

## Forming

### Wire Drawing (Drahtziehen)

- › Drawing dices (Ziehsteine)
- › E.g. from 5-30 mm down to  $> 0.03$  mm



# Forming and Subtractive Fabrication Technologies

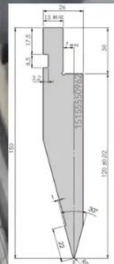
## Forming

### Wire Bending

› Manual or CNC



## Edging (Kanten)

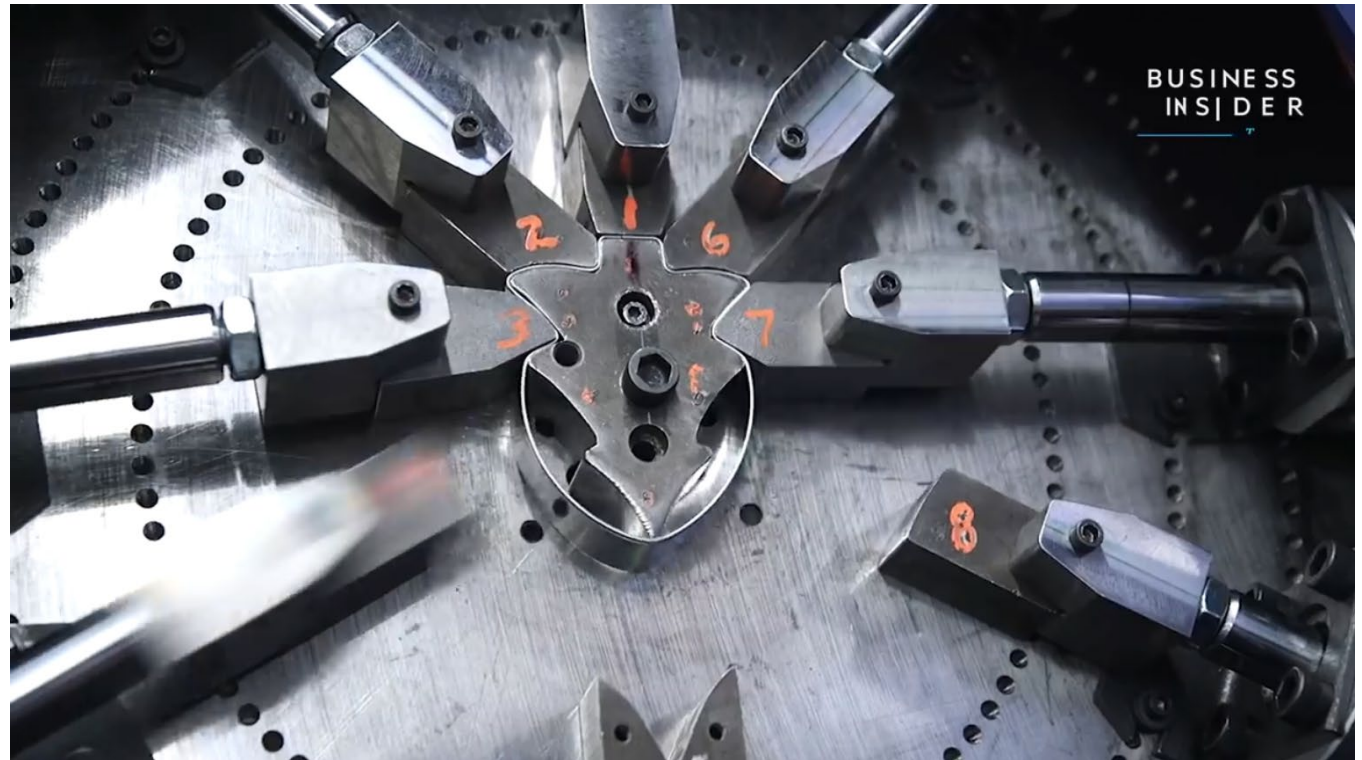




# Forming and Subtractive Fabrication Technologies

## Forming

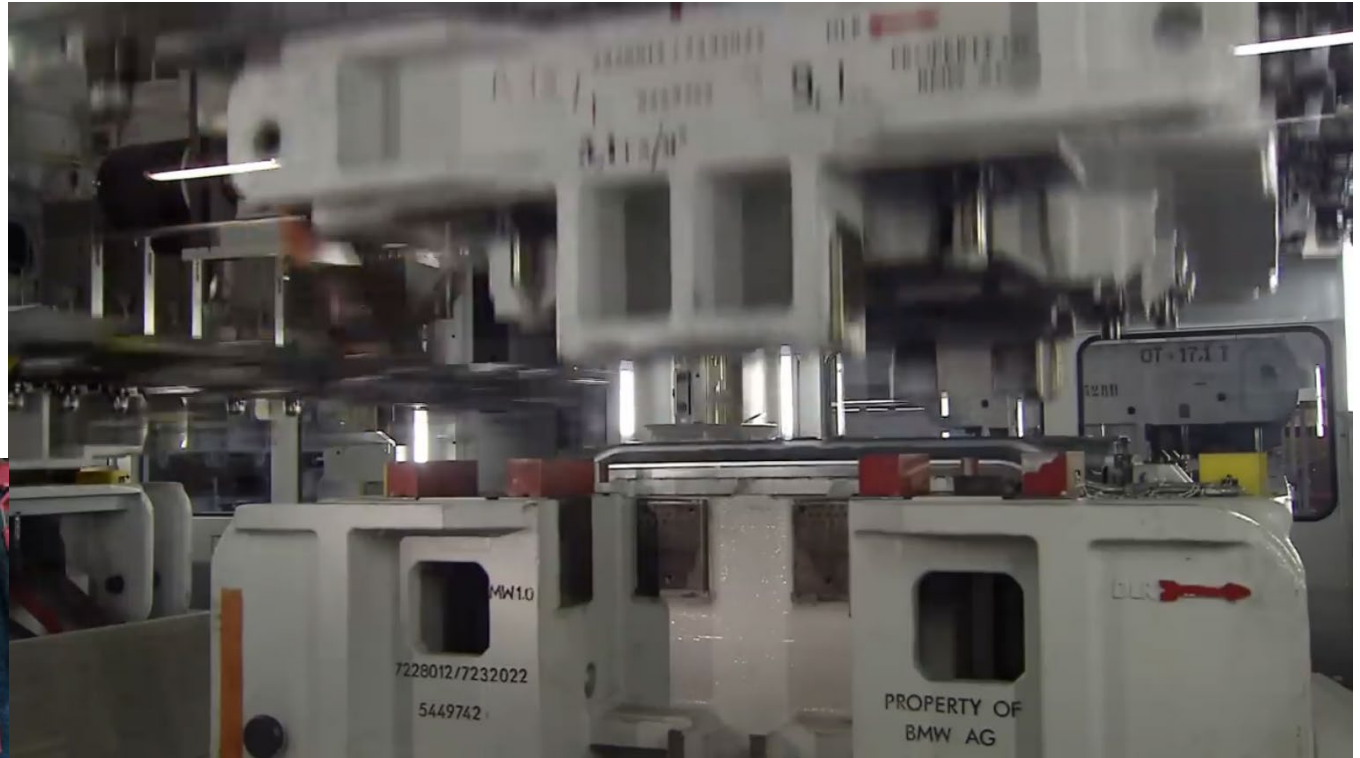
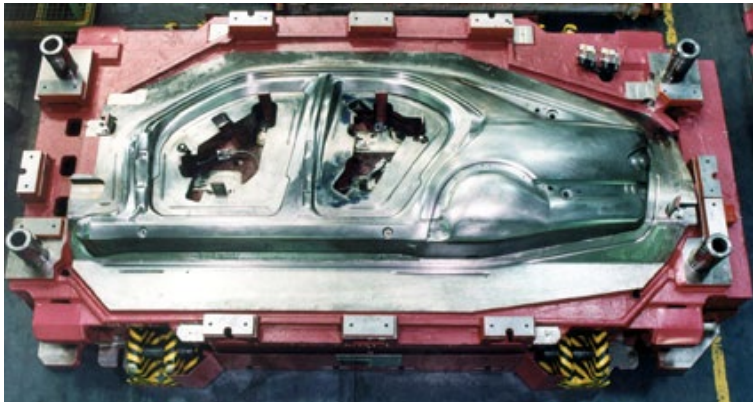
### Bending (Biegen)



# Forming and Subtractive Fabrication Technologies

## Forming

### Deep Drawing (Tiefziehen)





What are the main dis-/advantages of forming technologies?



# Forming and Subtractive Fabrication Technologies

## Forming

### Key Advantages

- › Ideally no waste of material
- › Robust objects
- › Fast fabrication
- › Low costs

### Key Disadvantages

- › Limited design options
- › Material warping due to deformation
- › Material fatigue due to processing

# Forming and Subtractive Fabrication Technologies

## Subtractive Technologies

# Subtractive Technologies

# Forming and Subtractive Fabrication Technologies

## Subtractive Technologies

### Punching (Stanzen)

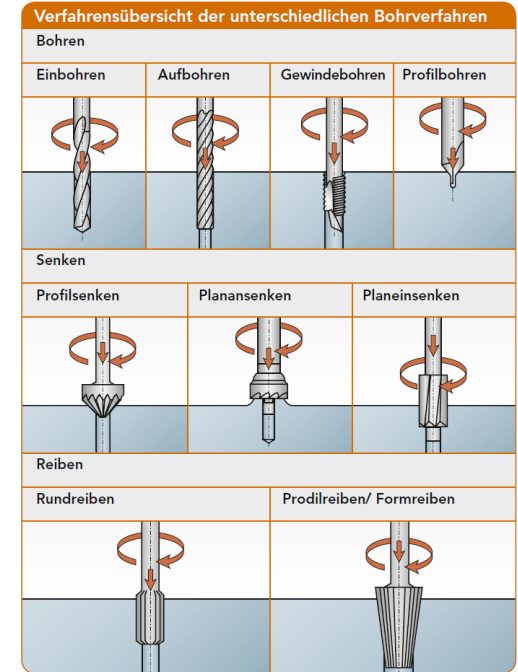
- › Shear cutting
- › Stamp (Stempel)



# Forming and Subtractive Fabrication Technologies

## Subtractive Technologies

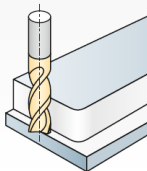
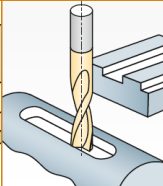
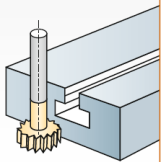
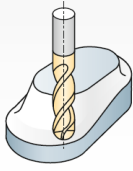
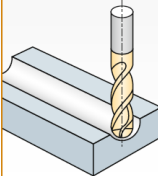
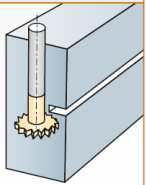
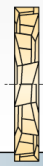
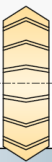
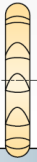




### Drilling (Bohren)



# Forming and Subtractive Fabrication Technologies

## Subtractive Technologies

### Milling (Fräsen)

Fräswerkzeuge/ Massiv-Werkzeuge			
Material der Schaftfräser z.B. Schnellarbeitsstahl, Vollhartmetall, Cermet			
Schaftfräser	Nutenfräser	T-Nutenfräser	
			
Gesenkfräser	Radiusfräser	Schlitzfräser	
			
Material der Aufsteckfräser Schnellarbeitsstahl, gelötete Hartmetall-Schneiden			
Scheibenfräser	Formfräser		
			
Walzenstirnfräser	Winkelstirnfräser	Kreissägeblatt	
			

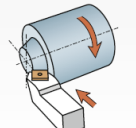
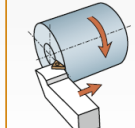
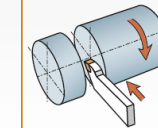
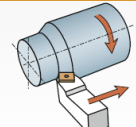
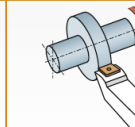
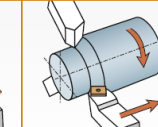
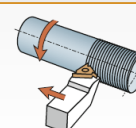
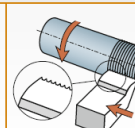
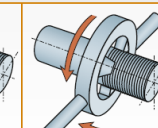
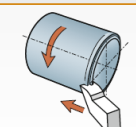
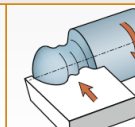
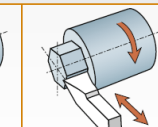
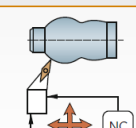
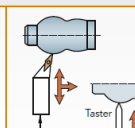
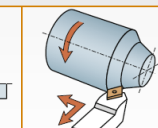
# Forming and Subtractive Fabrication Technologies

## Subtractive Technologies

### Turning Lathe (Drehmaschine)

- › Rotary bodies
- › Different tools/knives



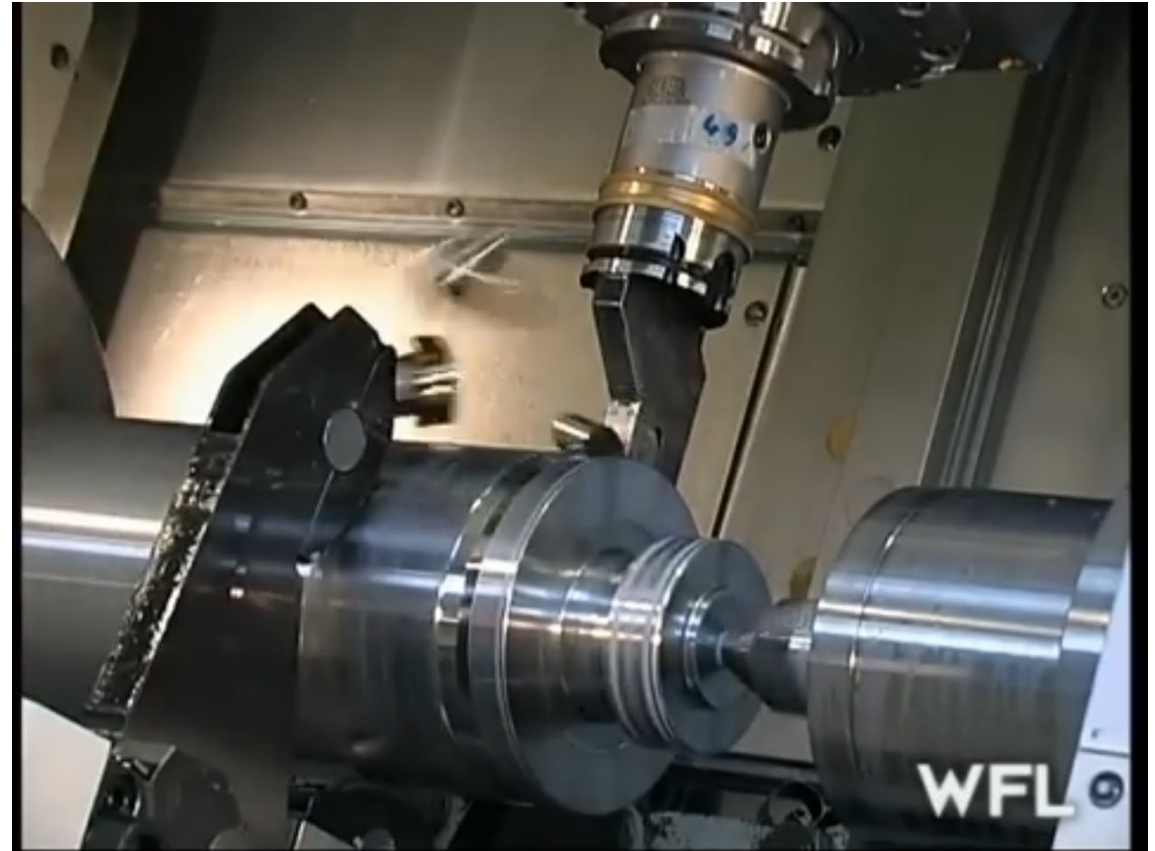
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Plandrehen	Stechdrehen	
		
Quer-Plandrehen	Längs-Plandrehen	Quer-Abstechdrehen
Runddrehen		
		
Längs-Runddrehen	Quer-Runddrehen	Schälldrehen
Schraubdrehen		
		
Gewindedrehen	Gewindestrehen	Gewindeschneiden
Schraubdrehen		
		
Längs-Profildrehen	Quer-Profildrehen	Quer-Unrunddrehen
Formdrehen		
		
NC-Formdrehen	Nachformdrehen	Kegeldrehen

# Forming and Subtractive Fabrication Technologies

## Subtractive Technologies

### Combination

- › Multiple degrees of freedom (DOF)
- › CNC lathe with drill and mill
- › Automatic measurements

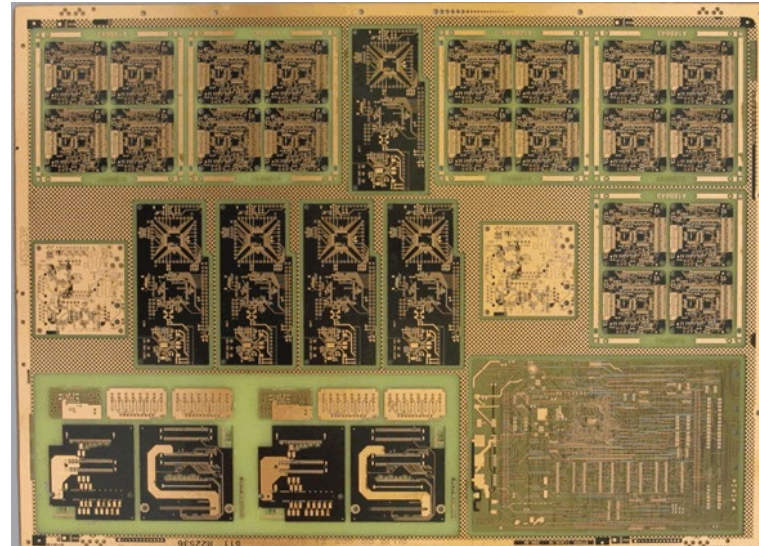
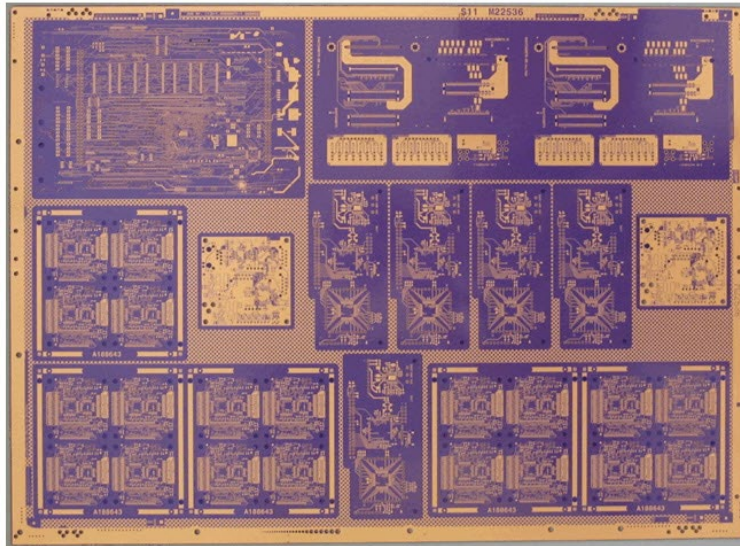




# Forming and Subtractive Fabrication Technologies

## Subtractive Technologies

### Etching (Ätzen)



Lecture on its own:  
Electronic Circuit Design.

# Forming and Subtractive Fabrication Technologies

## Subtractive Technologies

What are the main dis-/advantages of subtractive technologies?



# Forming and Subtractive Fabrication Technologies

## Subtractive Technologies

### Key Advantages

- › High surface accuracy
- › High stability

### Key Disadvantages

- › Large waste of material
- › Local material defects, e.g. due to heating
- › (Remaining surface roughness)

# Forming and Subtractive Fabrication Technologies

## Questions?

What are your questions?



# Project

## Ordering of Components

## Project

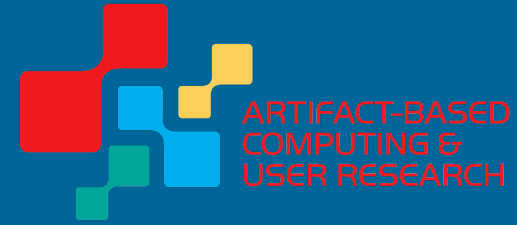
### Ordering of Components

## Available Material

- › Soldering materials and consumables
- › Basic components (e.g., resistors, LEDs, buttons, cables, ...)
- › Diverse microcontrollers
- › Many components available in our conglomeration box (inspiration and stroke of luck)

## Octopart BOM Tool

- › Bill of Materials
- › Shared online list for ordering components:  
<https://octopart.com/de/bom-tool/pguU9v8C>
- › Purchase from [mouser.at](https://www.mouser.at) (and [reichelt.at](https://www.reichelt.at) if necessary)



# Project

## Lab Introduction

Today:  
Groups 1-5



# Design & Fabrication

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Technische Universität Wien

Artifact-Based Computing & User Research (<http://media.tuwien.ac.at>)  
[florian.wolling@tuwien.ac.at](mailto:florian.wolling@tuwien.ac.at), [ambika.shahu@tuwien.ac.at](mailto:ambika.shahu@tuwien.ac.at)

