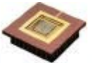
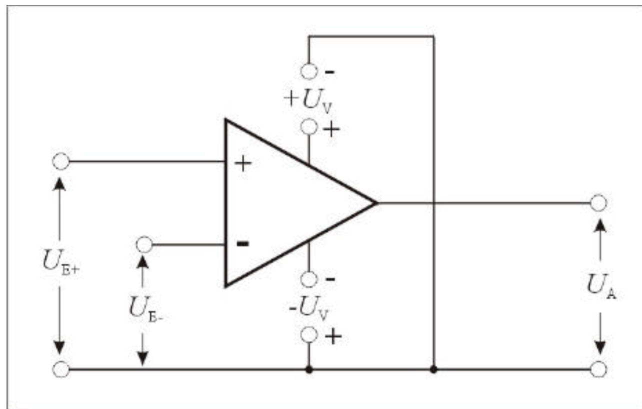
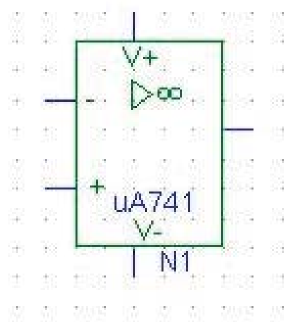


8 Operationsverstärker

In der Analogtechnik werden häufig *Operationsverstärker* eingesetzt.

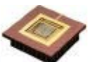


Schaltsymbol nach DIN

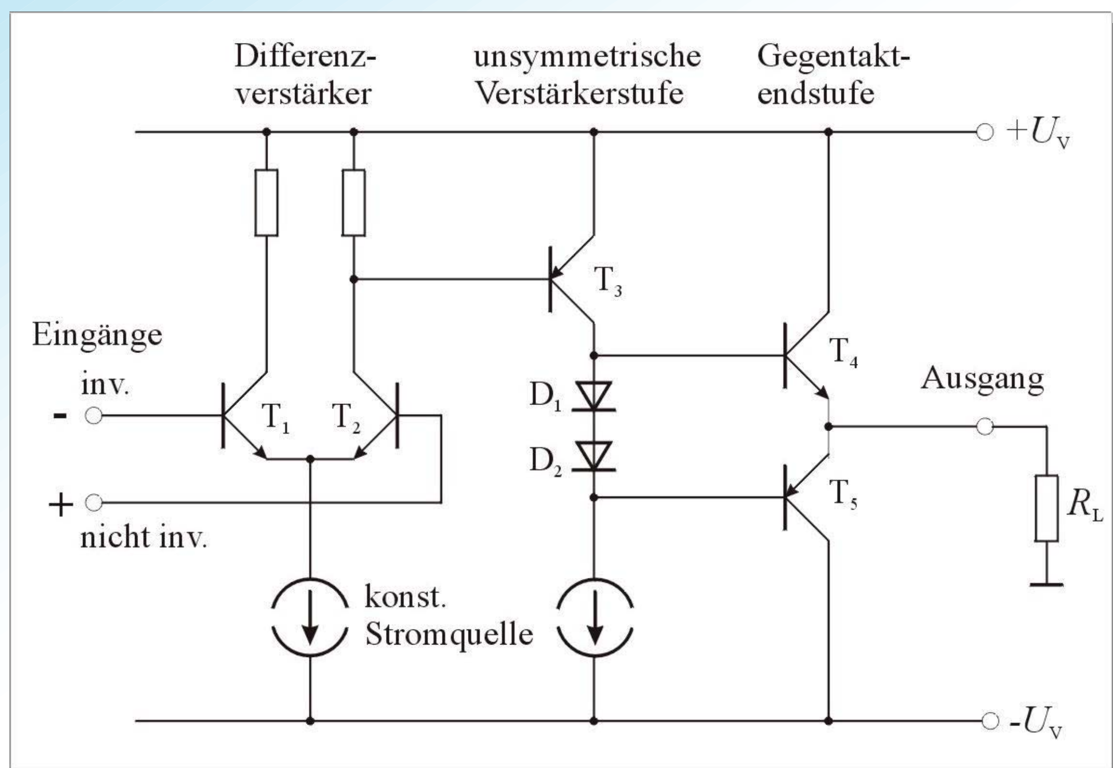


Diese Verstärker haben folgende Eigenschaften:

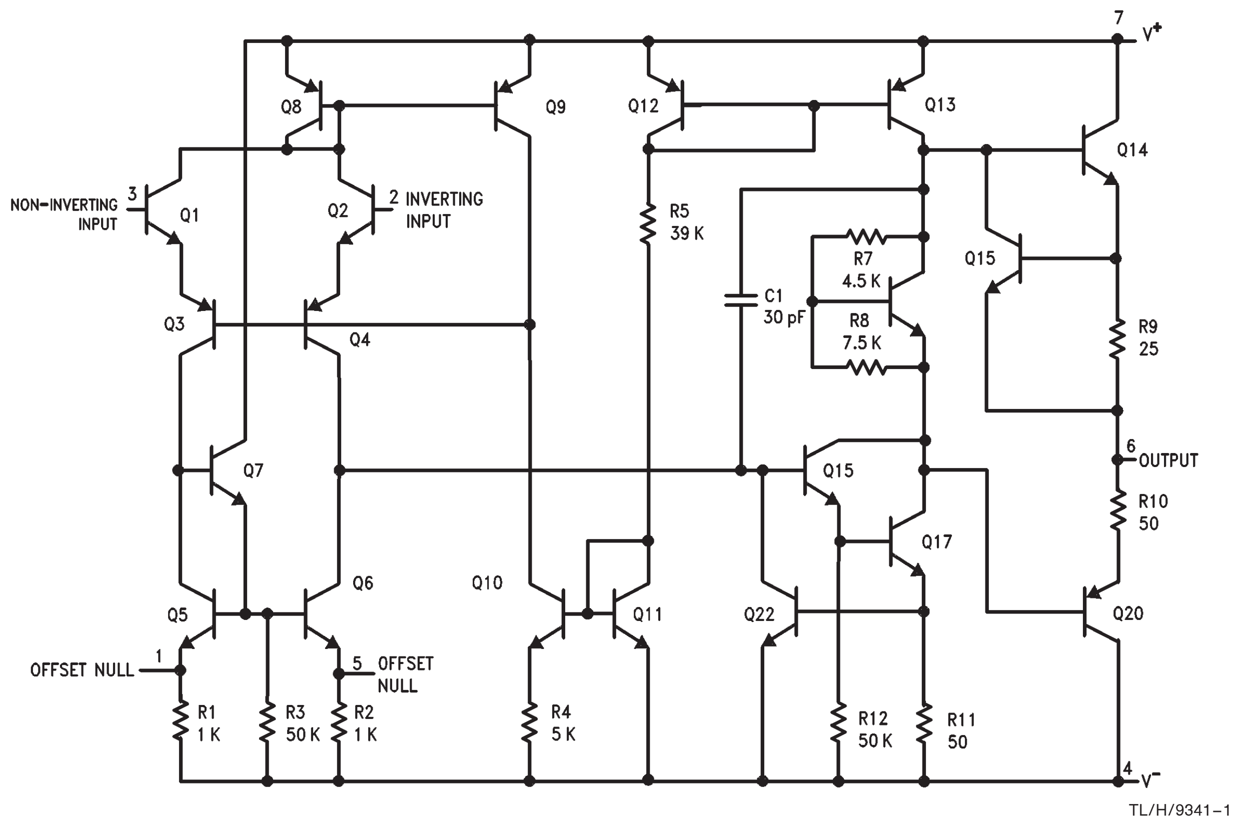
1. Sehr hohe Spannungsverstärkung $(10^4 < v_U < 10^6)$
2. Die erste Stufe ist als Differenzverstärker ausgebildet.
3. Hohe Gleichtaktunterdrückung der Eingangssignale
4. Sehr großer Eingangswiderstand
5. Alle Verstärkerstufen sind gleichspannungsgekoppelt.
6. Sehr kleiner Ausgangswiderstand



8.1 Aufbau eines mehrstufigen Operationsverstärkers



Schematic Diagram



General Description LM741

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709.

They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications.

The amplifiers offer many features which make their application nearly foolproof:

overload protection on the input and output
no latch-up when the common mode range is exceeded,
as well as freedom from oscillations.

The LM741C/LM741E are identical to the LM741/LM741A except that the LM741C/LM741E have their performance guaranteed over a 0°C to +70°C temperature range, instead of -55°C to +125°C.

Datenblätter (National Semiconductors)

http://www.national.com/pf/LM/LM741.html

http://pac.lrz-muenchen.de (Proxy)

General Description TL082

These devices are low cost, high speed, dual JFET input operational amplifiers with an internally trimmed input offset voltage (BI-FET II™ technology).

They require low supply current yet maintain a large gain bandwidth product and fast slew rate. In addition, well matched high voltage JFET input devices provide very low input bias and offset currents.

The TL082 is pin compatible with the standard LM1558 allowing designers to immediately upgrade the overall performance of existing LM1558 and most LM358 designs.

These amplifiers may be used in applications such as high speed integrators, fast D/A converters sample and hold circuits and many other circuits requiring low input offset voltage, low input bias current, high input impedance, high slew rate and wide bandwidth.

The devices also exhibit low noise and offset voltage drift.

Datenblätter (National Semiconductors)

http://www.national.com/pf/TL/TL082.html

General Description LF157

LF155/LF156/LF157 Series Monolithic JFET Input Operational Amplifier

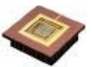
These are the first monolithic JFET input operational amplifiers to incorporate well matched, high voltage JFETs on the same chip with standard bipolar transistors (BI-FET™ Technology). These amplifiers feature low input bias and offset currents/low offset voltage and offset voltage drift, coupled with offset adjust which does not degrade drift or common-mode rejection. The devices are also designed for high slew rate, wide bandwidth, extremely fast settling time, low voltage and current noise and a low 1/f noise corner.

Applications

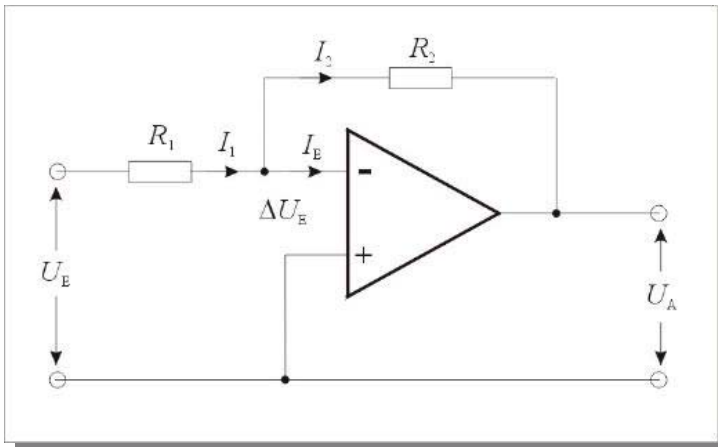
- Precision high speed integrators
- Fast D/A and A/D converters
- High impedance buffers
- Wideband, low noise, low drift amplifiers
- Logarithmic amplifiers
- Photocell amplifiers
- Sample and Hold circuits

Datenblätter (National Semiconductors)

http://www.national.com/pf/LF/LF157.html



Das einfachste Beispiel ist der invertierende Verstärker mit Gegenkoppelung:



Der Eingangsstrom ist

$$I_1 = I_2 + I_E \qquad (8.1)$$

Mit dem Eingangswiderstand r_E des OP wird

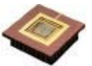
$$I_1 = \frac{U_E - \Delta U_E}{R_1}, \quad I_2 = \frac{\Delta U_E - U_A}{R_2}, \quad I_E = \frac{\Delta U_E}{r_E} \qquad (8.2)$$

Damit folgt

$$\frac{U_E - \Delta U_E}{R_1} = \frac{\Delta U_E - U_A}{R_2} + \frac{\Delta U_E}{r_E} \qquad (8.3)$$

und

$$\frac{U_A}{R_2} = -\frac{U_E}{R_1} + \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{r_E}\right)\Delta U_E \qquad (8.4)$$



Die Differenzspannung zwischen den beiden Eingängen wird

$$\Delta U_E = \frac{U_A}{v} \qquad (8.5)$$

Setzt man das in (8.4) ein, erhält man

$$\frac{U_A}{R_2} = -\frac{U_E}{R_1} + \frac{U_A}{v}\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{r_E}\right) \qquad (8.6)$$

Die Ausgangsspannung wird dann

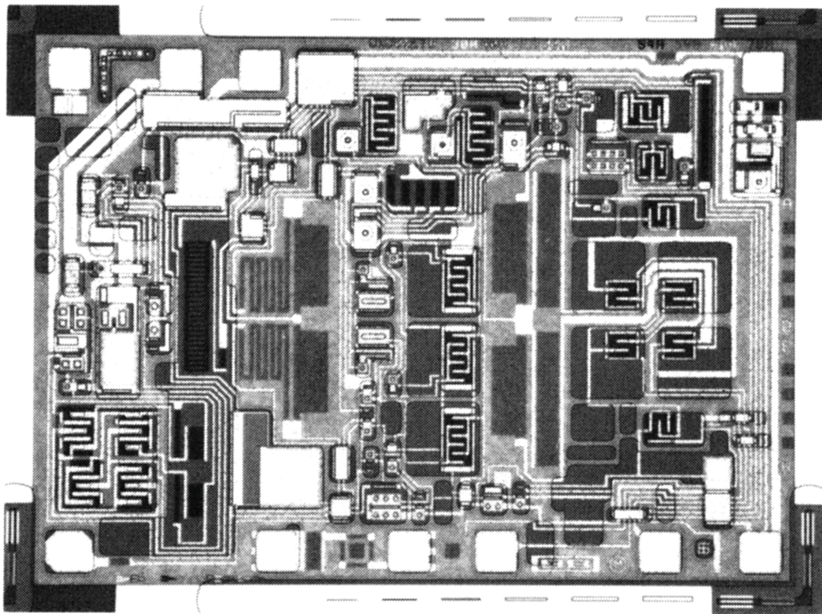
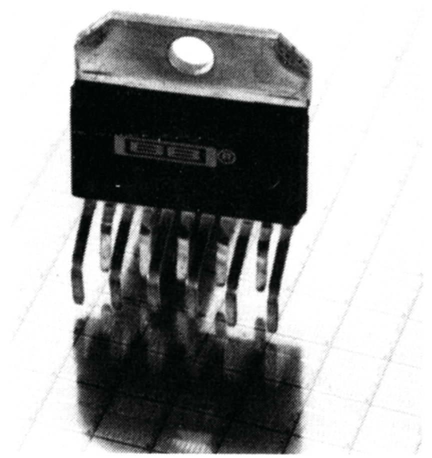
$$U_A = -\frac{U_E}{R_1\left[\frac{1}{R_2} - \frac{1}{v}\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{r_E}\right)\right]} \qquad (8.7)$$

Da die Verstärkung $v >>> 1$ ist, vereinfacht sich diese Beziehung auf

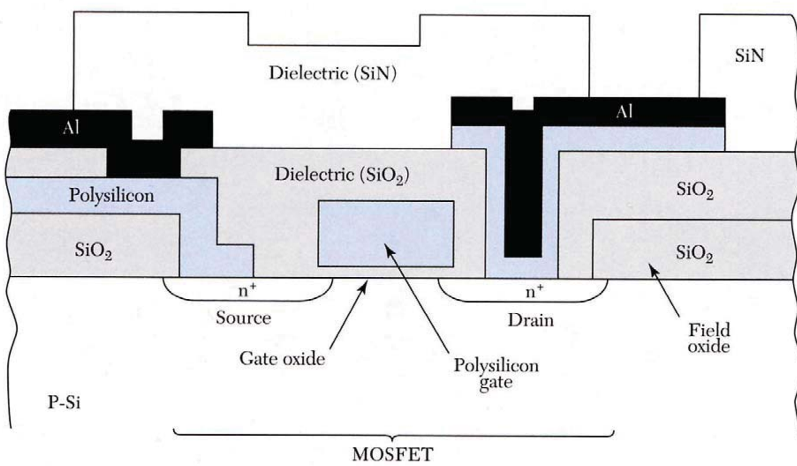
$$U_A = -\frac{R_2}{R_1} U_E \qquad (8.8)$$

Die Verstärkung hängt nicht mehr von den individuellen Eigenschaften des Operationsverstärkers ab. Sie wird nur noch vom Verhältnis der Widerstände der äußeren Beschaltung bestimmt. Die Verstärkerschaltung ist daher extrem linear.

Analoge integrierte Schaltungen

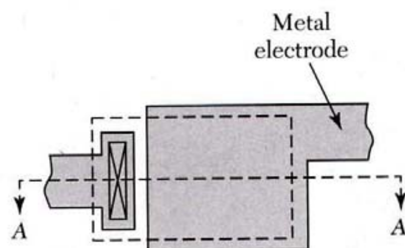
a) Chip-Aufnahme eines schnellen Operationsverstärkers	b) einbaufertiger Operationsverstärker
	

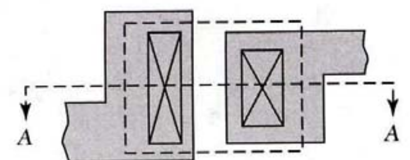
E. Riedle Physik[LMU]

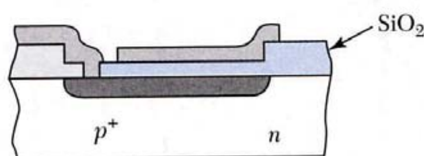


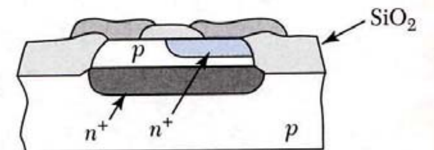
MOSFET Transistor

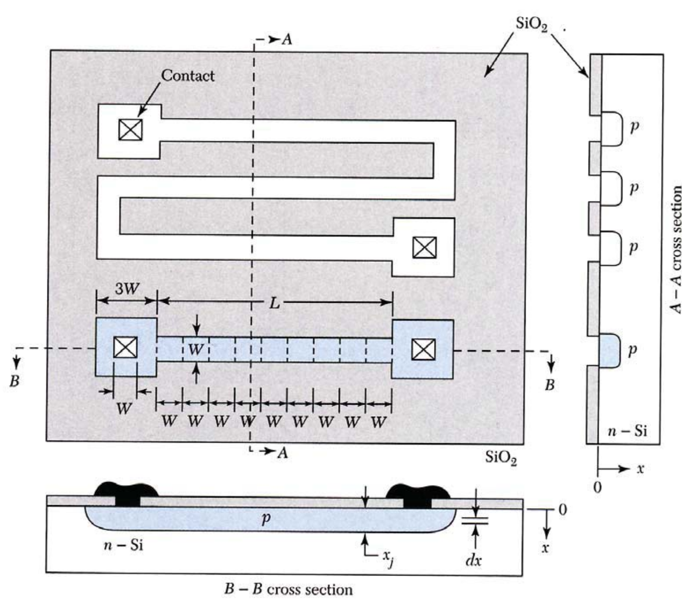
Kondensatoren



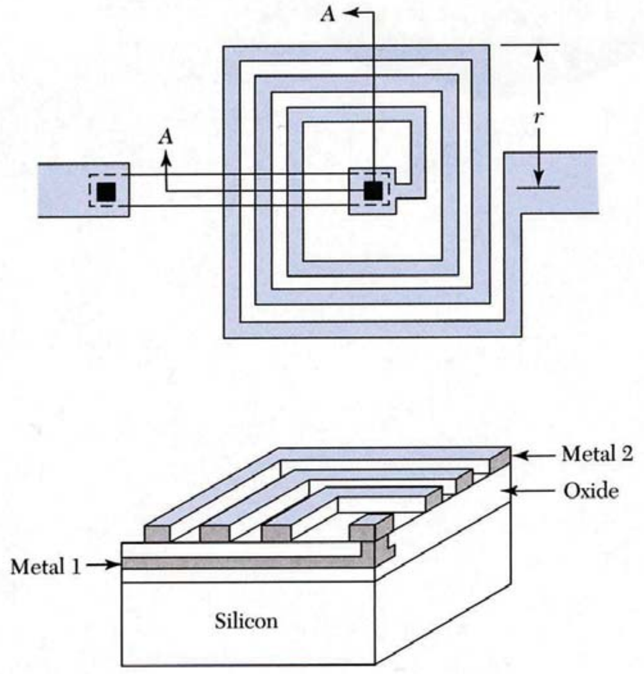




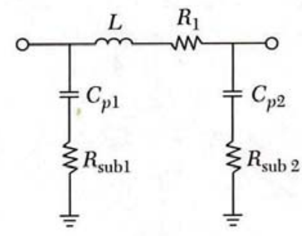


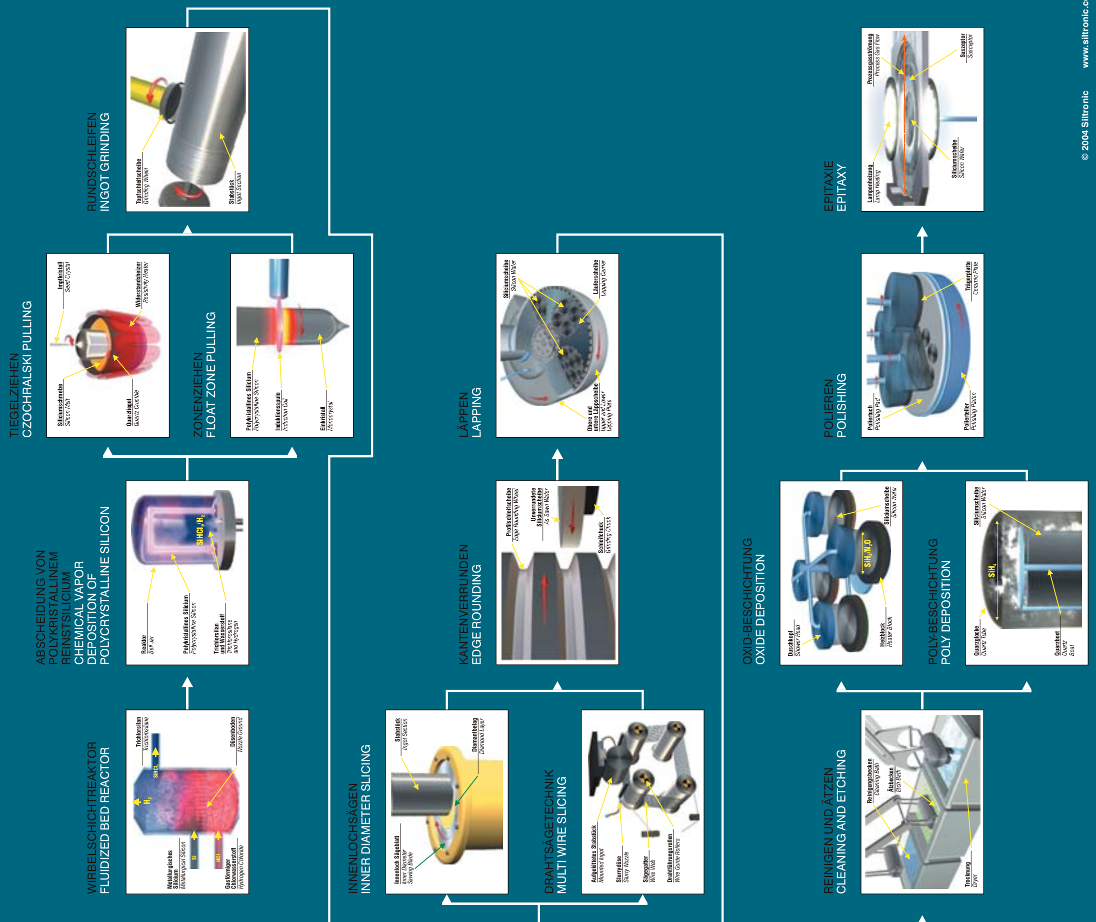


Widerstand

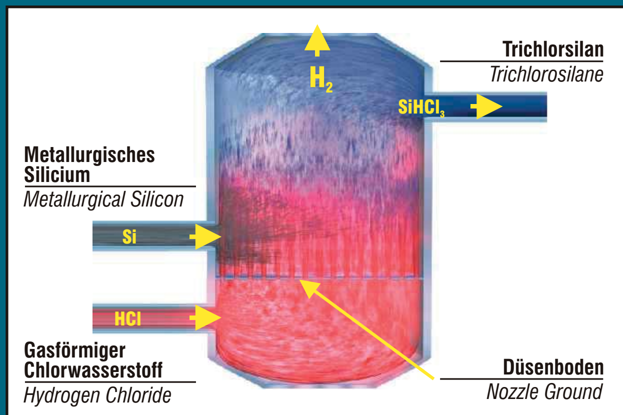


Spule

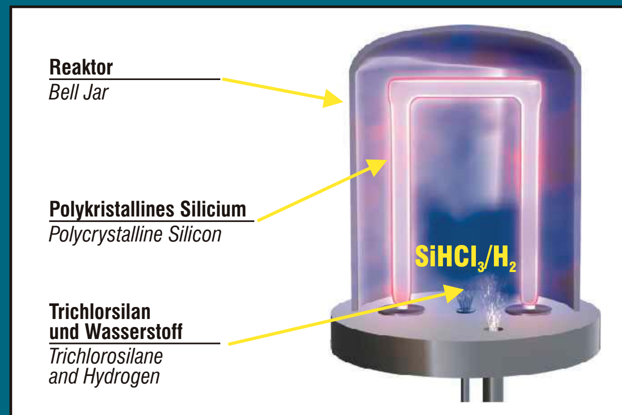




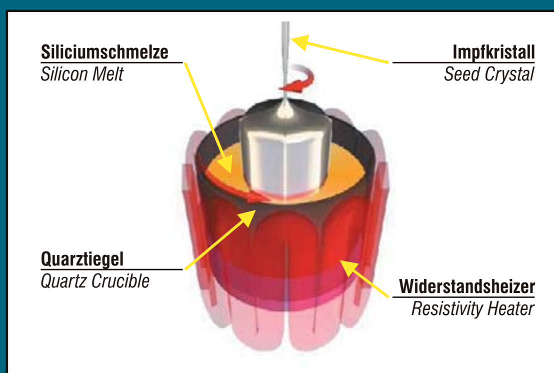
WIRBELSCHICHTREAKTOR
FLUIDIZED BED REACTOR



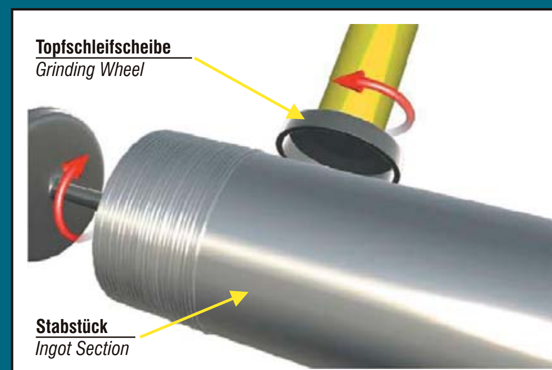
ABSCHEIDUNG VON POLYKRISTALLINEM REINSTSILICIUM
CHEMICAL VAPOR DEPOSITION OF POLYCRYSTALLINE SILICON



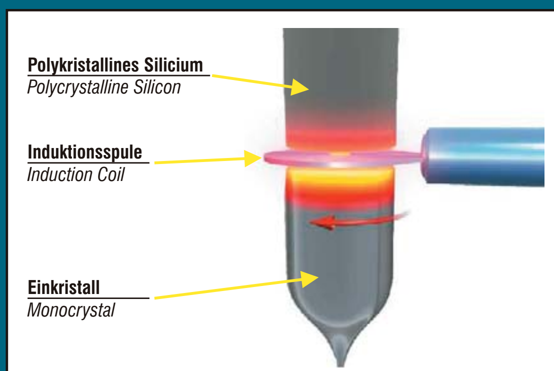
TIEGELZIEHEN
CZOCHRALSKI PULLING



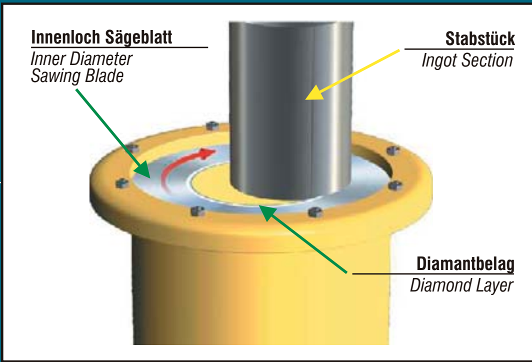
RUNDSCHLEIFEN
INGOT GRINDING



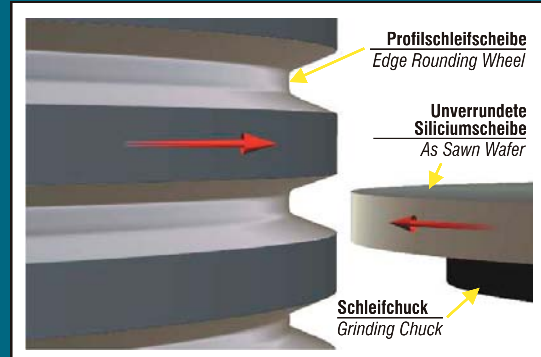
ZONENZIEHEN
FLOAT ZONE PULLING



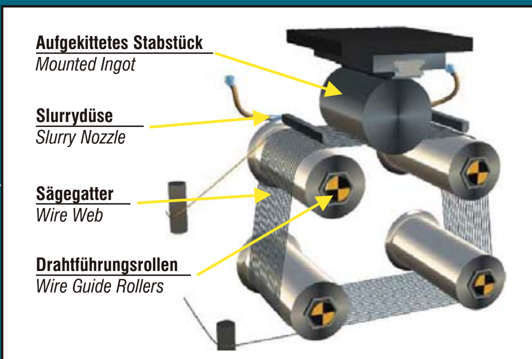
INNENLOCHSÄGEN
INNER DIAMETER SLICING



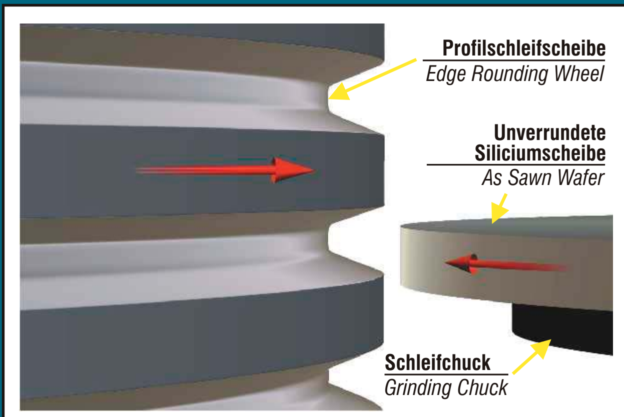
KANTENVERRUNDEN
EDGE ROUNDING



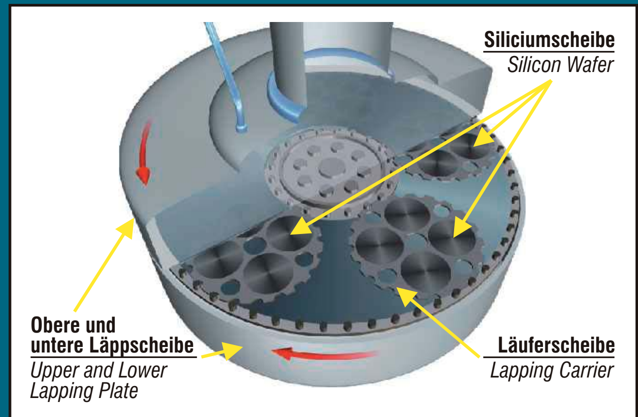
DRAHTSÄGETECHNIK
MULTI WIRE SLICING



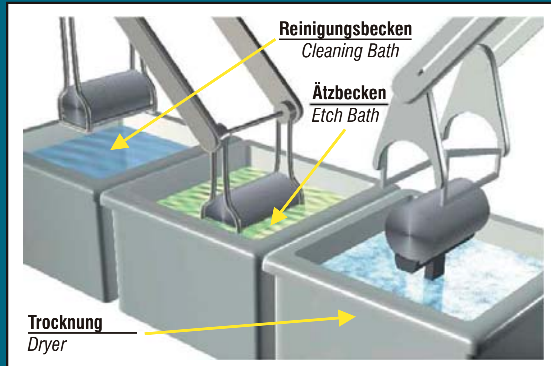
KANTENVERRUNDEN
EDGE ROUNDING



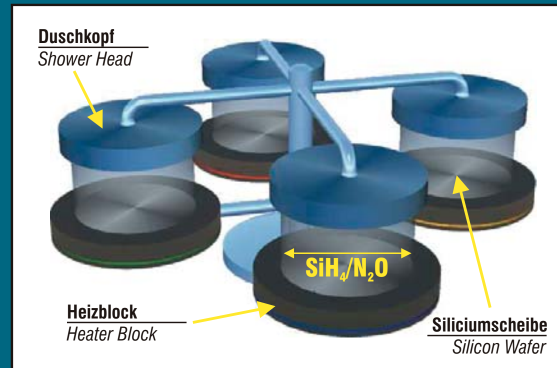
LÄPPEN
LAPPING



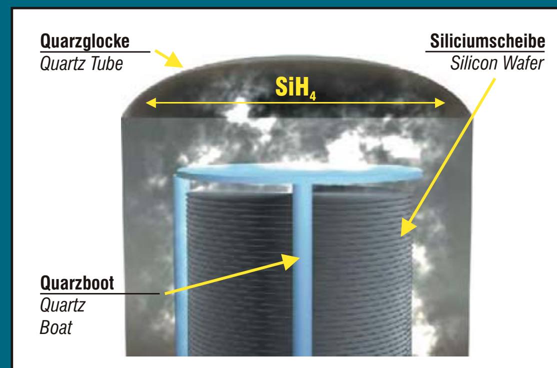
REINIGEN UND ÄTZEN
CLEANING AND ETCHING



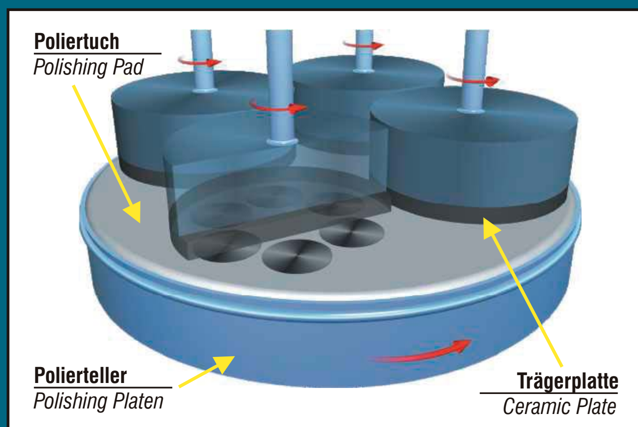
OXID-BESCHICHTUNG
OXIDE DEPOSITION



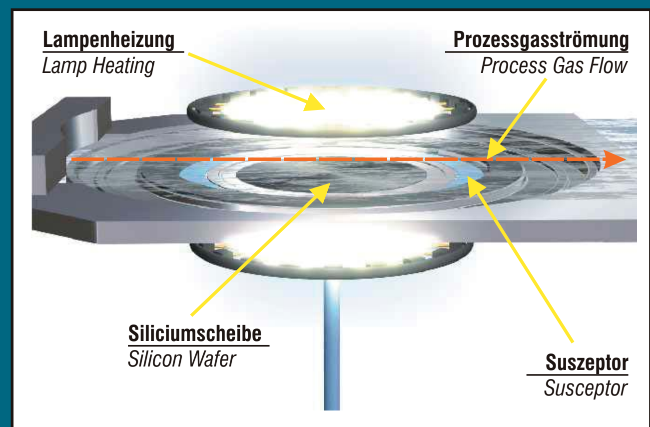
POLY-BESCHICHTUNG
POLY DEPOSITION

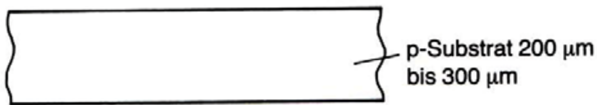


POLIEREN
POLISHING



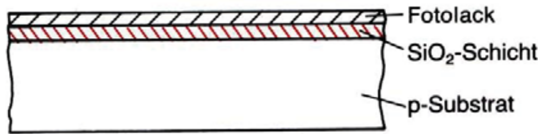
EPITAXIE
EPITAXY



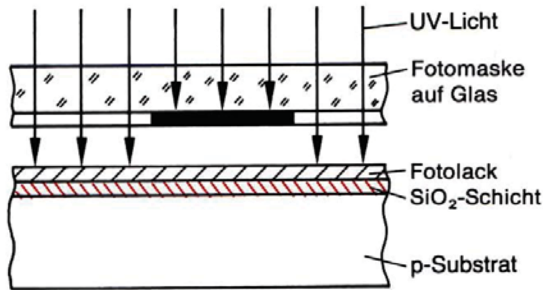


Ausgangsmaterial: p-dotiertes Silizium

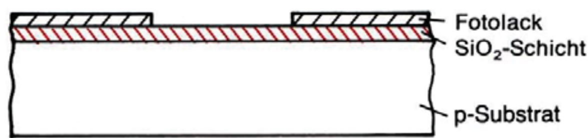
Oxidation zu Siliziumdioxid



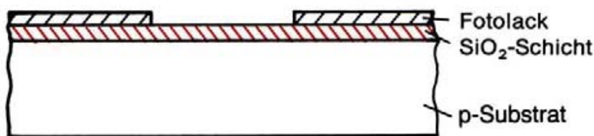
Aufbringen des Fotolacks

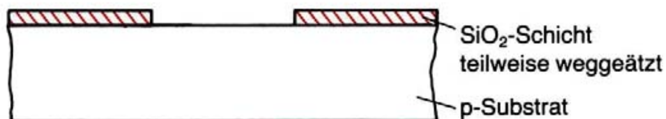


Belichten über eine Fotomaske

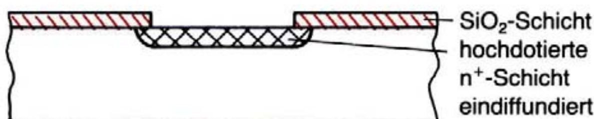


Entfernen des nicht belichteten Fotolacks

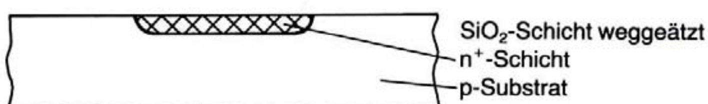




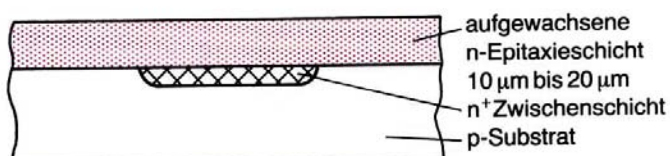
Wegätzen des SiO_2 an den nicht beschichteten Stellen --> **Maske**



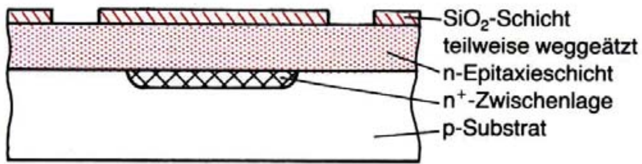
Eindiffundieren von n^+



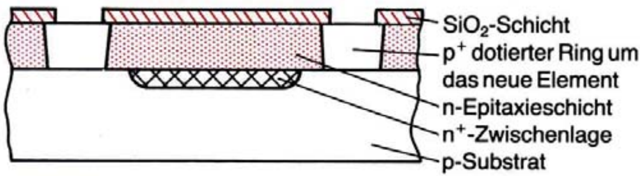
Entfernen der Maske



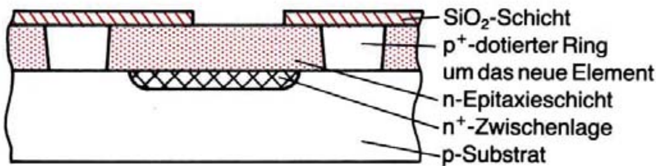
Auswachsen einer n-Epitaxie-Schicht



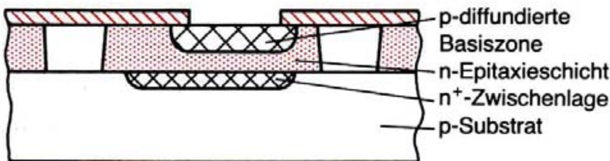
Erzeugen, Maskieren, Ätzen und Reinigen einer SiO_2-Schicht



Eindiffundierung eines p^+-dotierten Ringes um das zukünftige Bauteil

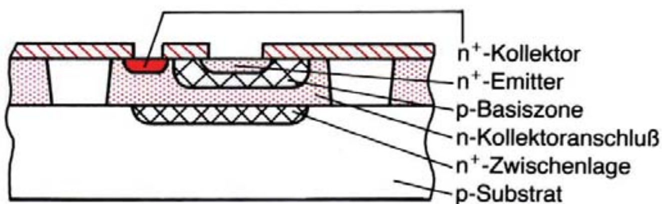


Erzeugen, Maskieren, Ätzen und Reinigen einer SiO_2-Maske für den Basisbereich

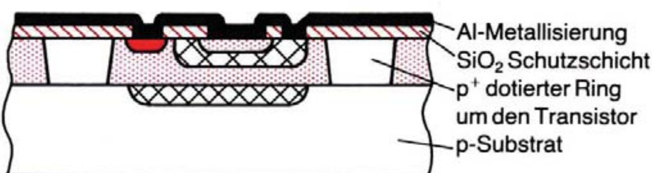


Diffundieren der Basiszone

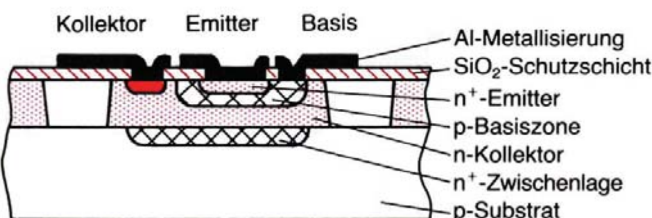
Bipolar Transistor in Silizium Planartechnik



Erzeugen, Maskieren, Ätzen und Reinigen einer SiO_2-Maske für Emitter und Kollektor-Anschluß. Diffundieren dieser Bereiche.



Metallisieren der Oberflächen



Wegätzen der überflüßigen Metallisierung