Sinterguide

This guide helps you understand the factors influencing the coloration and translucency of zirconia and eliminate sources of error for proper sintering.

1. Furnace maintenance

Most common reasons for a bad color result after sintering:

- Wrong amount of thermal energy
- Accumulation of impurities

For both reasons, the furnace is responsible. It contains wearing parts such as heating elements and thermocouples. Continuous monitoring of the furnace is therefore advisable in order to ensure consistent quality.

The following is a suggested routine for quality assurance:

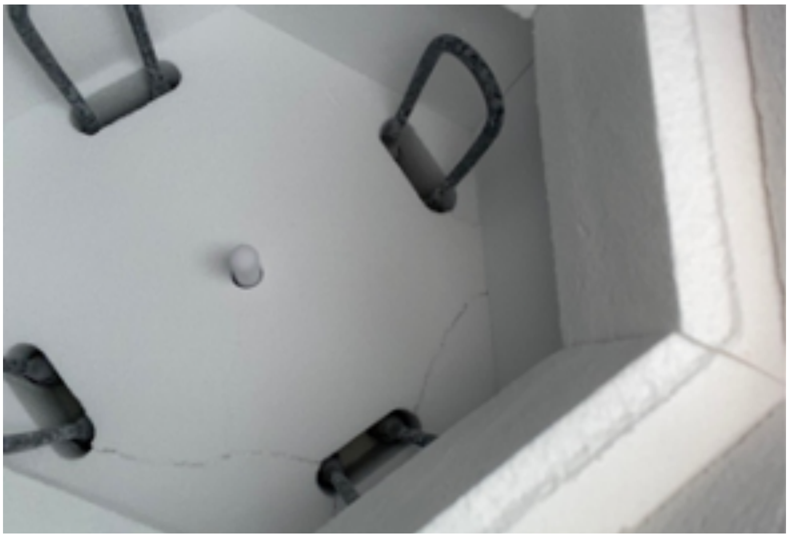
Furnace maintenance

- Visual check of the heating elements
- Determination of the firing accuracy
- Cleaning fire

1.1 Heating elements – visual check (weekly)

Regardless of whether heating elements are made of silicon carbide (SiC) or molybdenum silicide (MoSi2), they should always be of the same color. If this is not the case with $MoSi_2$ heating elements, a cleaning firing may be necessary (See chapter 1.3).

For more information, please refer to the furnace manual.



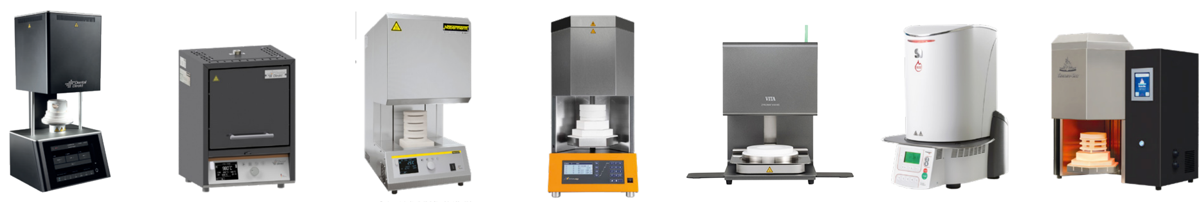
TIP:
Use your selfie camera to view the heating elements in the furnace chamber.

Fig. 1: $MoSi_2$ heating elements affected by deposits

Fig. 2: SiC heating elements affected by deposits

$MoSi_2$	usually „U“ shaped	ages more slowly	more maintenance-intensive
SiC	usually rod shaped	ages more quickly	less maintenance-intensive

Different sintering furnace manufacturers:



Type	DD Argus fire 674i (Dekema)	LHTCT 01/16 (Nabertherm)	LHT 02/17 LB (Nabertherm)	HTS-2/M/Zirkon-120 (Mimh Vogt)	ZYRCOMAT® 6100 MS (VITA®)	Programat S1 1600 (Ivoclar)	Denta Star P1 Plus (Thermo Star)
Heating elements	**Siliziumcarbid (SiC)**	**Siliziumcarbid (SiC)**	Molybdänsilizid ($MoSi_2$)	Molybdänsilizid ($MoSi_2$)	Molybdänsilizid ($MoSi_2$)	Molybdänsilizid ($MoSi_2$)	Molybdänsilizid ($MoSi_2$)

1.2 Determination of firing accuracy (every 6 months + as required/furnace calibration)

If the furnace overfires or underfires, the wrong color will appear in the restorations.

In addition to the heating elements, the temperature sensor (thermocouple) is also subject to certain aging and contamination influences, which can affect the temperature measurement.

So-called PTC (Process Temperature Control) rings are used to determine the firing accuracy. These are sintered with a special program and the known shrinkage of these rings allows the furnace temperature to be determined. Depending on the result, the furnace may have to be recalibrated.

Don´t be hesitate to contact us for more information or to purchase PTC rings.

1.3 Cleaning fire – using DD phoeniX

Regardless of the type of heating elements, impurities accumulate in the furnace chamber and can cause a color change of the constructions. Due to many further sintering processes, more and more accumulate in the furnace wall, which in the worst case »rain« down onto the zirconium restorations in concentrated form. For this purpose, carry out a cleaning firing with DD phoeniX at regular intervals.

Instructions for use DD phoeniX

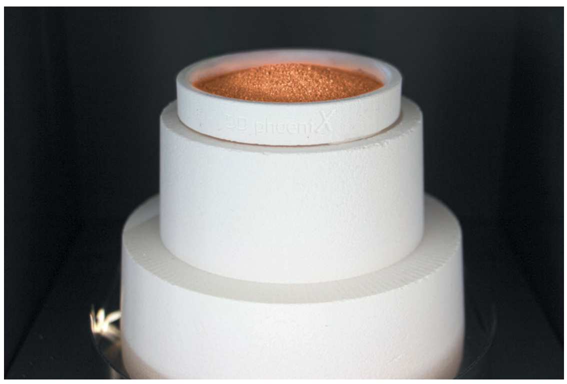


Fig. 3: Proper application and appearance of the powder before the cleaning firing.

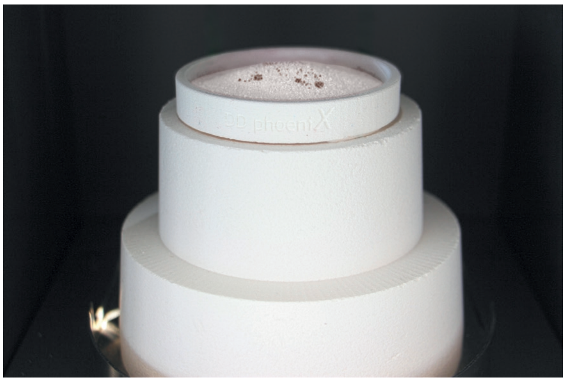


Fig. 4: Optics of the powder after carrying out the cleaning firing in case of deposits: brownish discolored residues

Possible yellow/green discoloration of MoSi2 heating elements:

Heating elements made of MoSi2 have an enveloping protective layer of SiO2. This continues to form during normal use. At some point, this layer becomes too thick and flakes off. Thus, the molybdenum can react with oxygen in the heating element. The typical green oxide can produce extreme green discoloration in the zirconia. The absence of the protective layer causes a greatly accelerated aging of the MoSi2 heating element. Also carry out a cleaning firing with DD phoeniX in order to »suck« impurities out of the furnace. Its very reactive surface binds the impurities leading to discoloration.

See also:
www.dentaldirekt.de/en/dd-journal/dd-phoenix

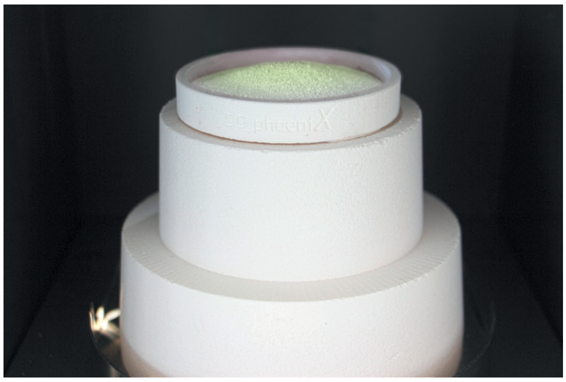
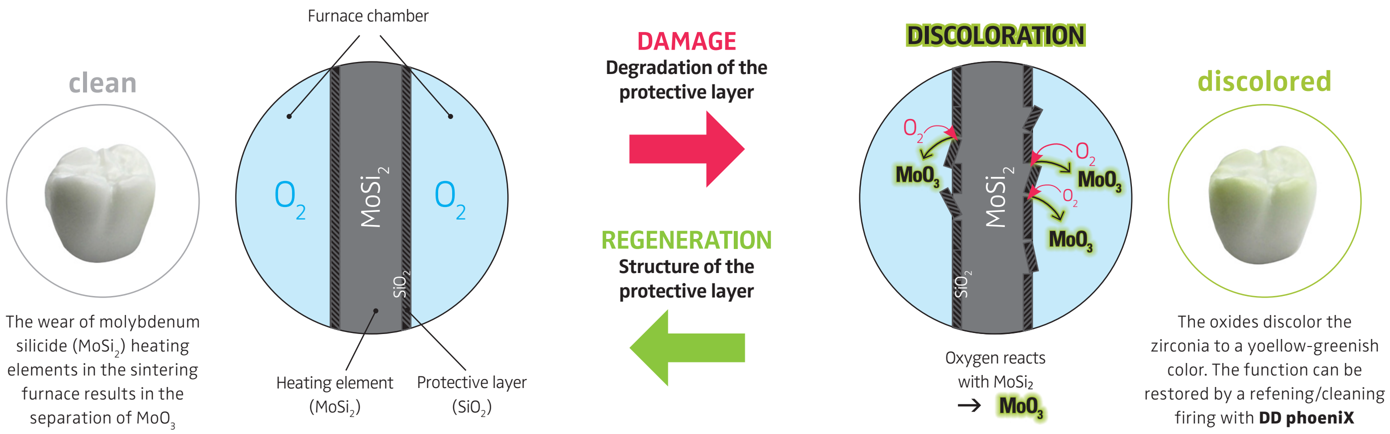


Fig. 5: Optics of the powder after carrying out the cleaning firing for the $MoSi_2$ discolorations: greenish discoloration.



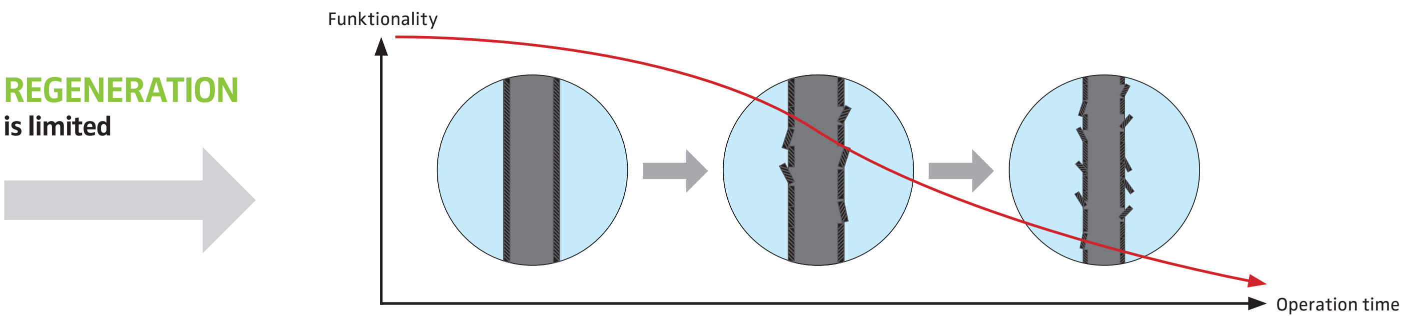


Fig. 6: Green discoloration due to deposited molybdenum (VI) oxide (MoO_3)

Fig. 7: Green discoloration due to deposited molybdenum(VI) oxide (MoO_3): stronger discoloration on solid pontics

Fig. 8: Green discoloration due to deposited molybdenum(VI) oxide (MoO_3): stronger discoloration on massive crowns

Fig. 9: Again, green discoloration of solid pontics or solid structures

2. Coloring and translucency

Coloring and translucency

Sintering temperature | Sintering program and furnace loading

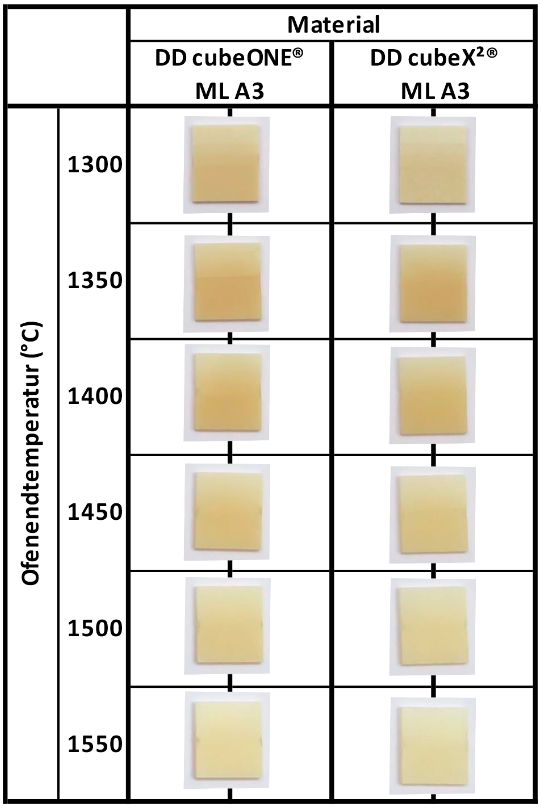
2.1 Sintering temperature

In addition to the exact composition of the added colorants, the sintering profile has a decisive influence on the development of the desired color. The sintering profile describes when and which amount of thermal energy is introduced into the zirconium oxide.
The amount of thermal energy determines where exactly in the structure the color oxides move. Both a too low temperature („too short migration paths"), as well as too high a temperature („too long migration paths") will result in incorrect integration. Furthermore, the migration of atoms through the thermal energy also causes shrinkage in the zirconium oxide.

The following graphic of the multilayers shows that the smooth transitions between the individual layers are only formed above a certain temperature:

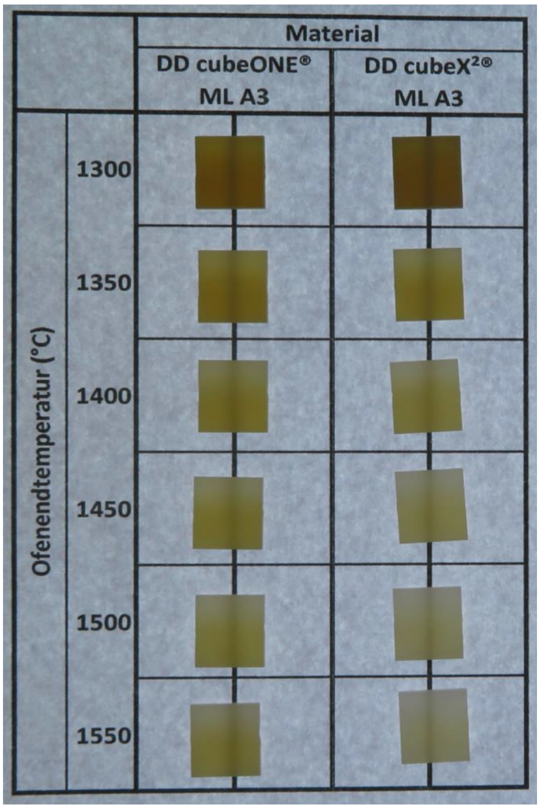
The zirconium oxides from Dental Direkt are set to a final sintering temperature of 1,450 °C.
This is the decisive factor for the development of color and translucency.

Too low temperature = too little translucency and too dark color
Too high temperature = higher/too high translucency and too light/bleached color



Ofenendtemperatur (°C)	Material: DD cubeONE® ML A3	Material: DD cubeX²® ML A3
1300		
1350		
1400		
1450		
1500		
1550		

Fig. 10:
In light booth with D65 Development and change of the color gradient over different sintering temperatures



Ofenendtemperatur (°C)	Material: DD cubeONE® ML A3	Material: DD cubeX²® ML A3
1300		
1350		
1400		
1450		
1500		
1550		

Fig. 11:
On light plate change of translucency from body to incisal edge via different sintering temperatures.

Examples: too much energy → Color too bright

Fig. 12:
Color effect of the crown from DD cube ONE® ML A3 is too bright. The incisal area is too white.

Fig. 13: The sintering temperature was clearly exceeded; the color was lost and the incisal edge appears more opaque on a bridge made of DD cube ONE® ML C2.

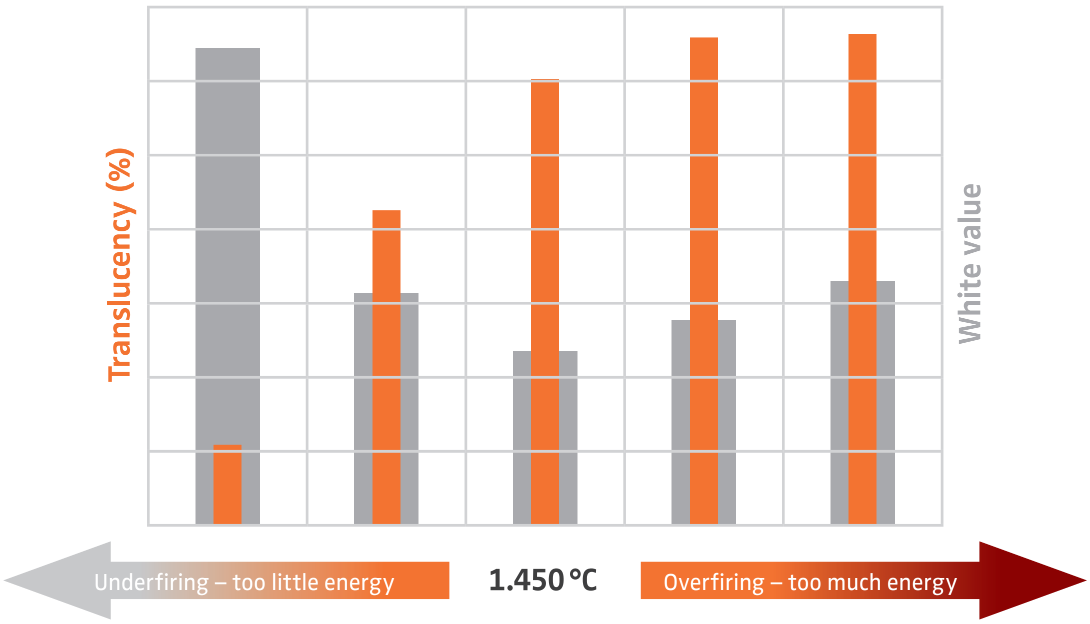
Examples: too less energy → Color too dark

Fig. 14: dark color effect due to insufficient energy input for crowns made of DD cube X²® ML A4

Fig. 15: clearly underbaked construction from DD cube ONE® ML C3: paint layers clearly visible

Fig. 16: white crown margins can also be a sign of insufficient energy input: here white crown margin of a DD cube ONE® ML A2

Furthermore, it should be noted that as the sintering temperature increases, the white value also increases. This is critical because the human eye associates a white value that is perceived as too high with opacity. The paradox is that although the measured translucency is higher, the perceived translucency is lower. The following graph illustrates this phenomenon. These measurements were taken on 1 mm thick platelets from the incisal area of the of DD cube ONE® ML A3

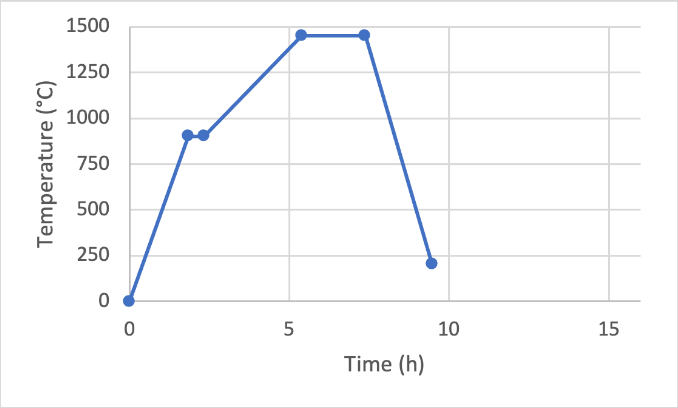


2.2 Sintering program and furnace loading

As already known, the right amount of thermal energy is needed for aesthetic results. Besides the accuracy of the furnace control, the furnace loading is also very important! The thermal energy is distributed to everything inside the furnace.

Below are our sintering curves with the recommended furnace loading:

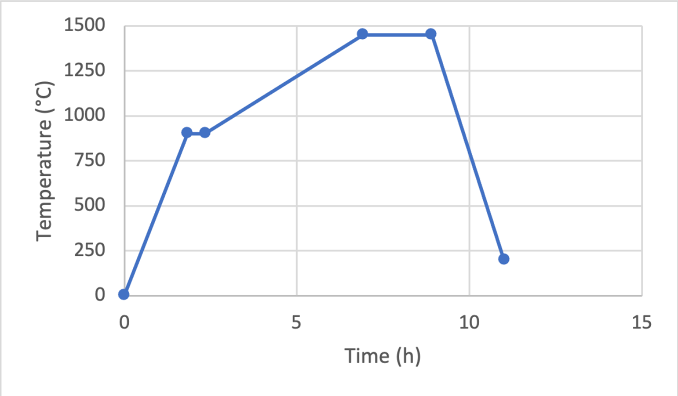
Standard program



Heating rate 1	8 °C / min. up to 900 °C
Holding time 1	30 min. at 900 °C
Heating rate 2	3 °C / min. up to 1.450 °C
Holding time 2	120 min. at 1.450 °C
Cooling rate	10 °C / min. up to 200 °C

If the DD Standard program contains too many units (3 levels) or very massive constructions has to be sintered, it may be that the thermal energy is not sufficient and the desired color will not be achieved.

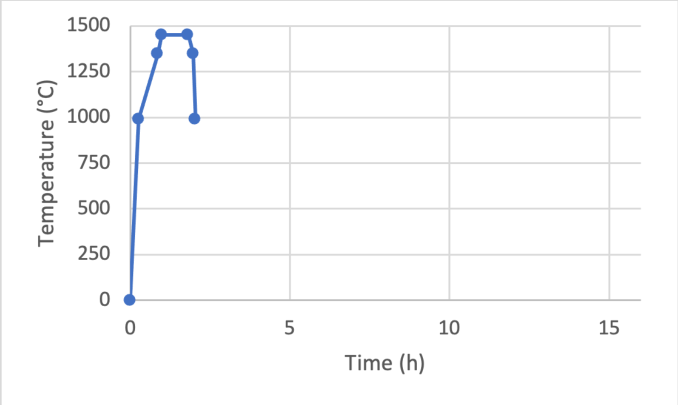
Massive program



Heating rate 1	8 °C / min. up to 900 °C
Holding time 1	30 min. at 900 °C
Heating rate 2	2 °C / min. up to 1.450 °C
Holding time 2	120 min. at 1.450 °C
Cooling rate	10 °C / min. up to 200 °C

Zirconium oxide is a poor conductor of heat. In concrete terms, this can mean that too fast heating rates do not lead to uniform heating of the zirconium. Especially in the case of long-span bridges with pontics, this can lead to esthetic and fit inconsistencies. The DD Massiv prevents these problems from occurring.

Speed program

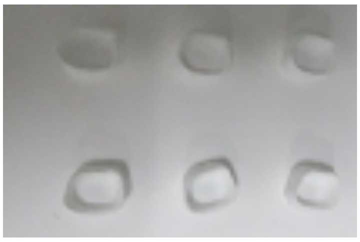


Speedsintering has been validated for the Dekema furnaces Austromat 664 and Austromat 674.

For both furnaces, strict parameters are specified:

- Sintering may only be carried out on one level
- Only single crowns may be sinterd
- The maximum wall thickness of these single-tooth crowns must not exceed 4mm
- A maximum of 3 crowns may be sintered in the Austromat 664, maximum of 6 crowns may sintered in the Austromat 674 (due to different furnace volumes)

Heating rate 1	60 °C/min. up to 990 °C
Heating rate 2	10 °C/min. up to 1350 °C
Heating rate 3	15 °C/min. up to 1450 °C
Holding time 1	50 min. / 80 min
Cooling rate 1	10 °C/min. up to 1350 °C
Cooling rate 2	Maximum cooling down to 990°C
Cooling rate 3	Open oven at 990°C and maximum cooling with the oven open



The two furnaces have different furnace chamber volumes. This must be taken into account in the energy input. A furnace volume that is twice as large means that twice as much air must be heated. In order to achieve uniform heating of the furnace at the decisive step of energy input at 1,450 °C, and thus the desired results, the holding time of the Austromat 674 is 30 minutes longer than that of the Austromat 664.

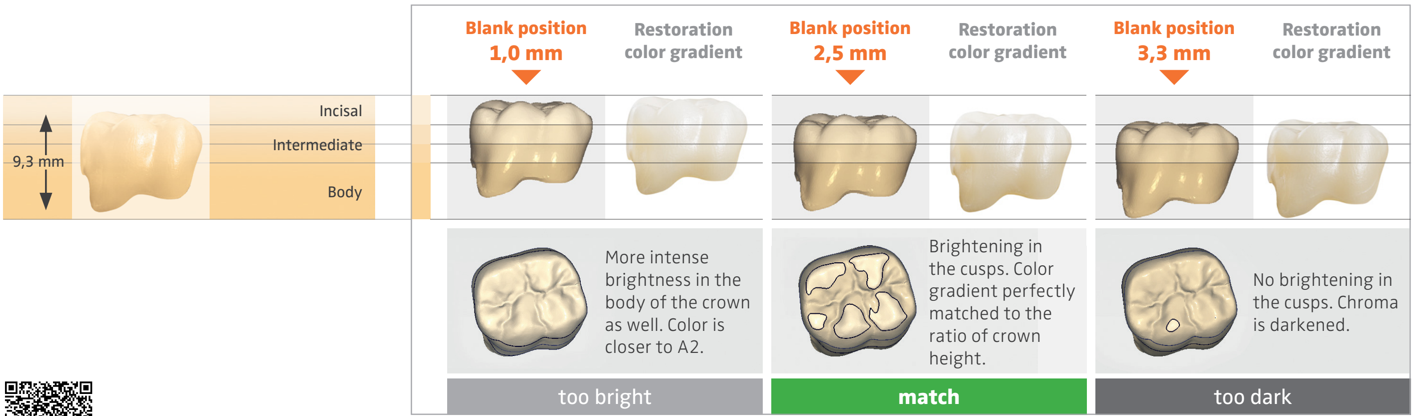
Proper nesting is also a factor to be considered for the final color effect of a restoration.

Layer heights, pre-sintered for your nesting software

Blank height (mm)	Layer 1+2: Incisal (mm / %)	Layer 3: Intermediate (mm / %)	Layer 4: Intermediate (mm / %)	Layer 5: Dentine (mm / %)
14 mm	3,5 / 24,9	2,1 / 15	2,1 / 15	6,3 / 45,1
18 mm	3,5 / 19,4	2,1 / 11,7	2,1 / 11,7	10,3 / 57,2
22 mm	3,5 / 15,9	2,1 / 9,6	2,1 / 9,6	14,3 / 64,9

Optimum CAM-Nesting:

Indication: Crown, tooth 46, Color A3 – **Blank:** DD cube ONE® ML, Height 14 mm, Color A3 – **CAM software:** DD smart CAM 2.0
Information on the height of the layers can be found in the Nesting recommendation at dentaldirekt.de/en/downloads.



dentaldirekt.de/en/dd-journal/
get-nesting-right-and-color-will-be-right-too

! You will achieve the best color match by individually positioning the restoration in the blank (match). Depending on the height of the restoration, the positioning of the incisal, intermediate layer an dentin can be individually adjusted in the DD smart CAM 2.0 software to achive the best possible color gradient. !

Fig. 17: too light color result due to too high positioning of the crown in the blank