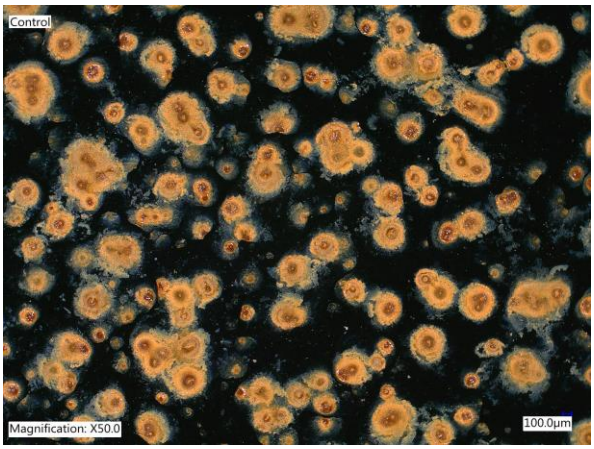

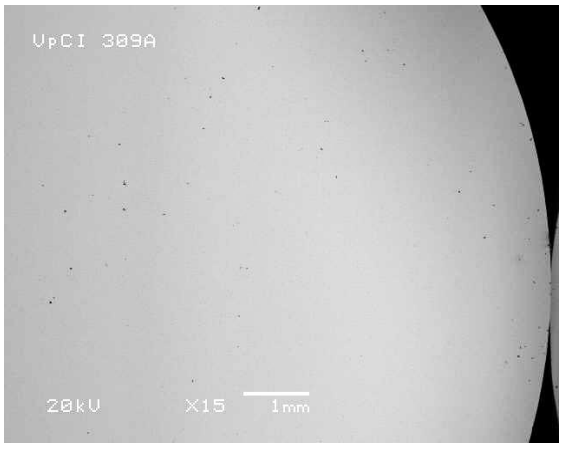

Laboratory Test to Evaluate the Vapor-Inhibiting Ability of VpCI309A for Temporary Protection of Ferrous Surfaces

For:

CORTEC Corporation

By

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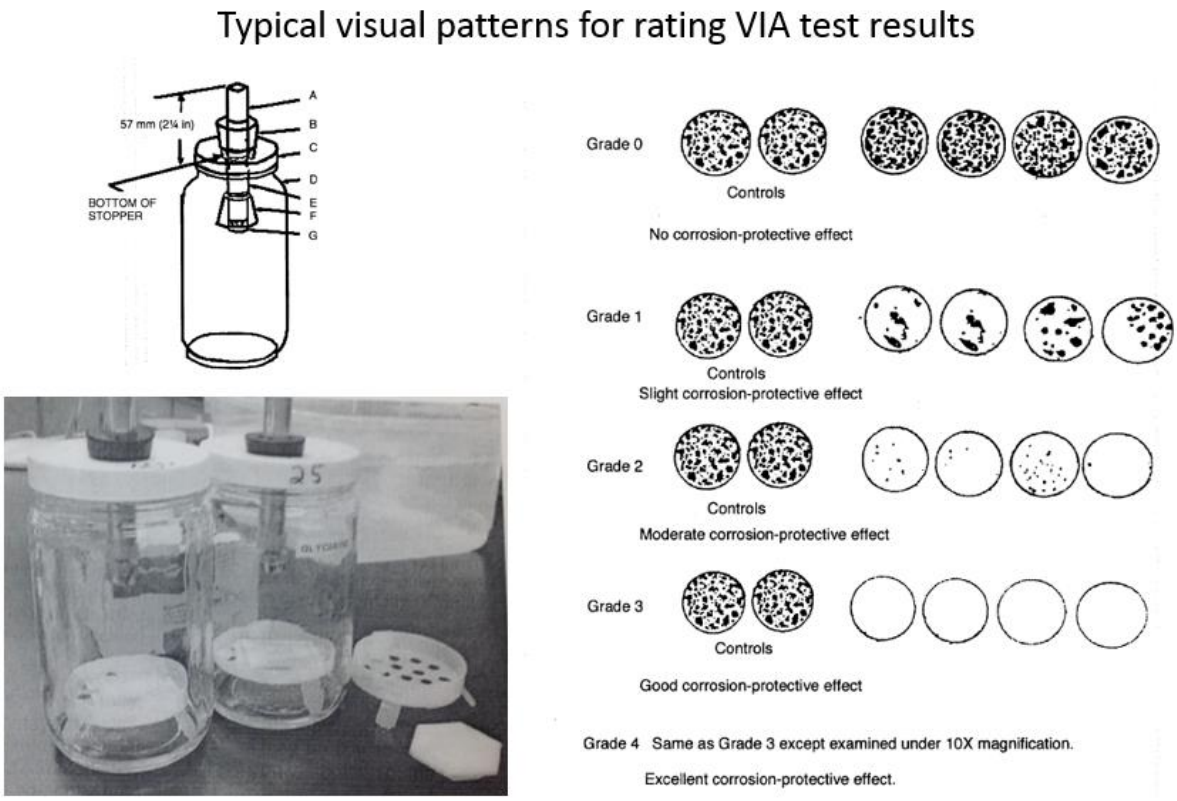
CORTEC CORPORATION
Enviromentally Safe VpCI®/MCI® Technologies

Corrosion behavior of carbon steel (UNS G10100) samples were studied in VpCI 309A vapor corrosion inhibitors using the NACE TM 208-2008 Standard Test Method. This laboratory test method evaluates the vapor-inhibiting ability (VIA) of various forms of VCI materials for temporary corrosion protection of ferrous metal surfaces. The VIA corrosion test method provides for standard conditions in a test jar of water-saturated, warm air without the presence of accelerating contaminants. Water vapor and VCI transport are confirmed and corrosion protection is evaluated in this test method. The VIA tests consist of four steps of sample conditioning or saturation for 20 hours at 22 ^{o}C, cooling cycle at 2^{o}C, pre-warming at 50^{o}C, followed by three hours at 22 ^{o}C for specimen conditioning. After the last three hour conditioning period, the steel samples were inspected for visible water condensation. Following verification of water condensation on each sample, visual examination of the surface was done and microscopic observation was conducted to determine the corrosion rating for each sample. The corrosion criteria for rating steel specimens consist of grade 0 through grade 4. To have a valid test, the control sample must have grade 0; samples with no inhibitor received worst grade. The control samples consistently rated a grade 0 for all VIA tests, therefore, validating the test method. Relative humidity and the temperature of each test jar were monitored by (Sensirion) sensors and data logging software.

VIA tests were conducted on 12 steel samples (three control samples and nine in presence of VpCI 309. The VIA visual observations are shown in Figures 1-8. The corrosion rating per TM-208 indicated that the control sample had Grade 0, while VpCI- 309A rating was Grade 3. Surface condition of samples after VIA tests is shown in Figures 8-31. The VpCI 309A tested samples showed superior corrosion protection during VIA tests with grade of 3.

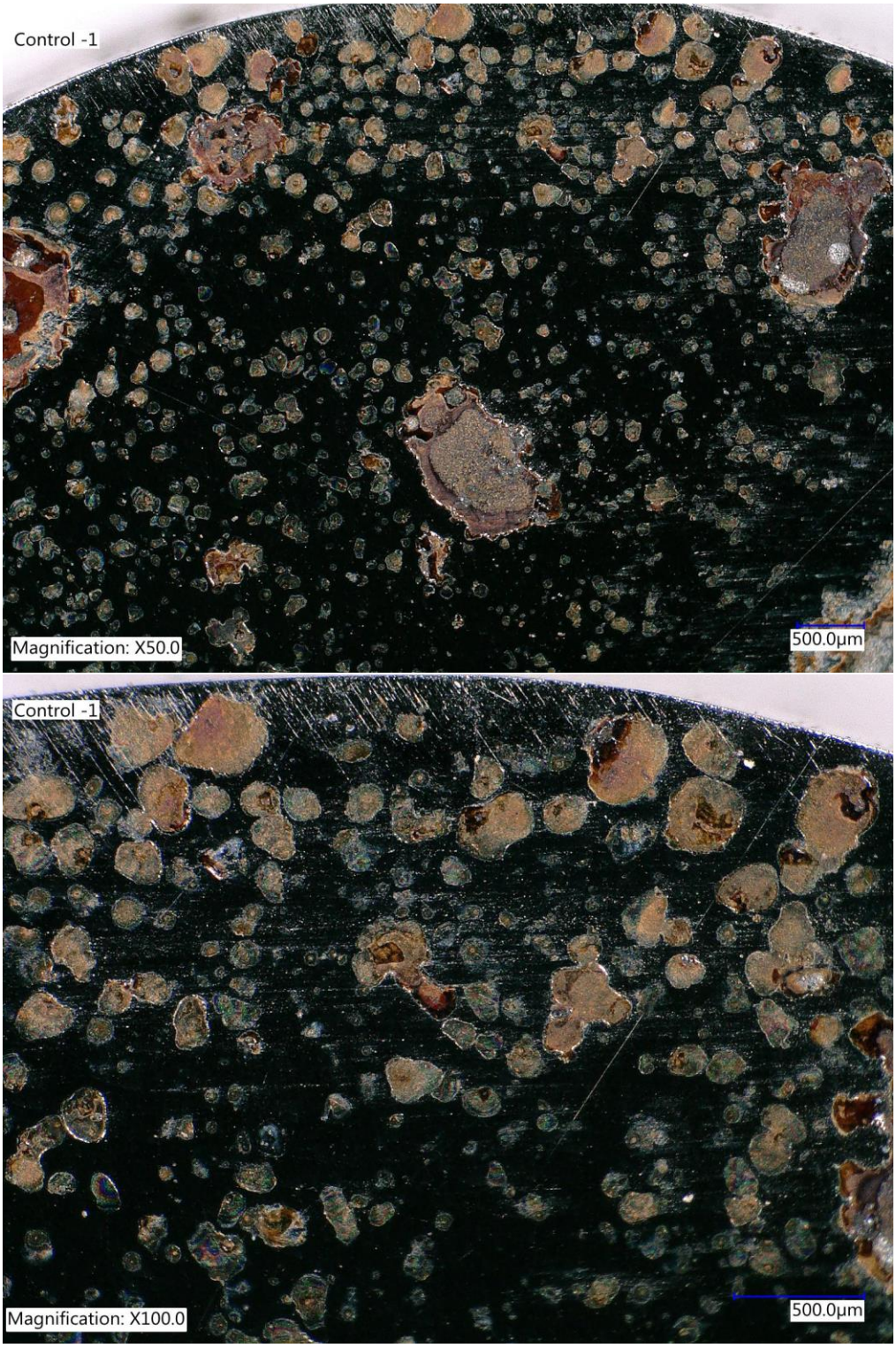
In summary, VpCI 309A vapor corrosion inhibitors showed an excellent corrosion protection in the NACE TM 208-2008 Standard Test Method. Average grade of 3 achieved while the control samples demonstrated a grade 0. Therefore, the VIA test results were validated.



Control Six samples of VIA test in VpCI 309A

Figure 1: Photo of the VIA test samples after completion of test cycle.

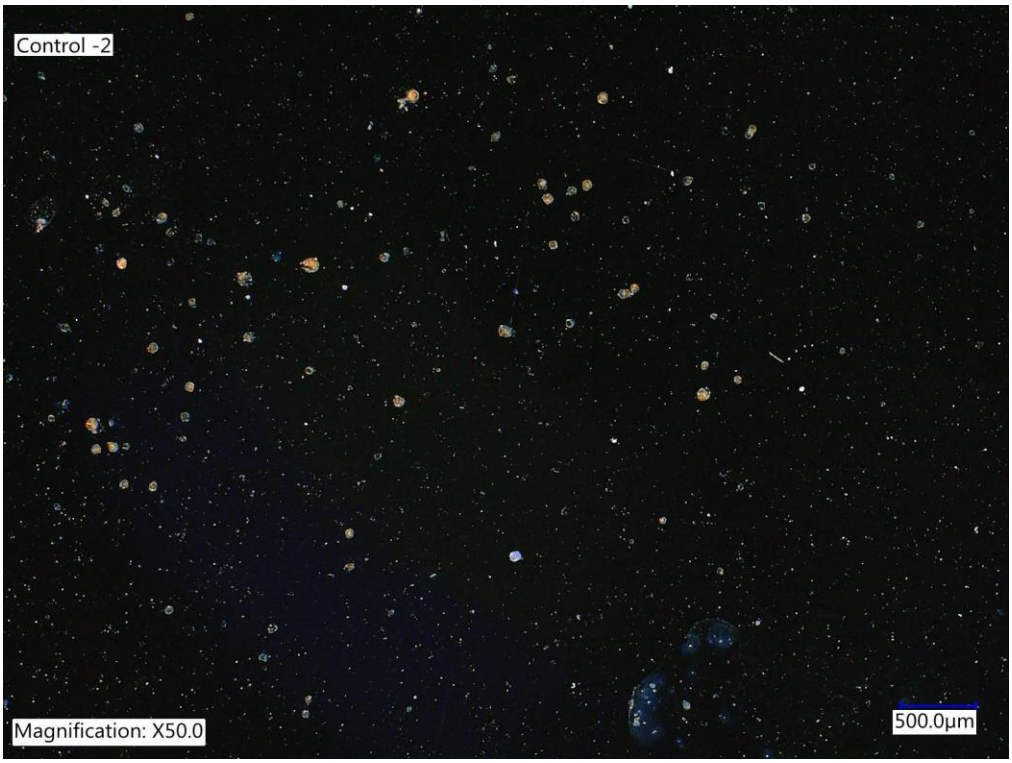
TM 208 VIA test on VpCI 309A



Control, Grade 0

Fig. 2: Optical micrographs of the Control sample#1 in TM0208 VIA test.

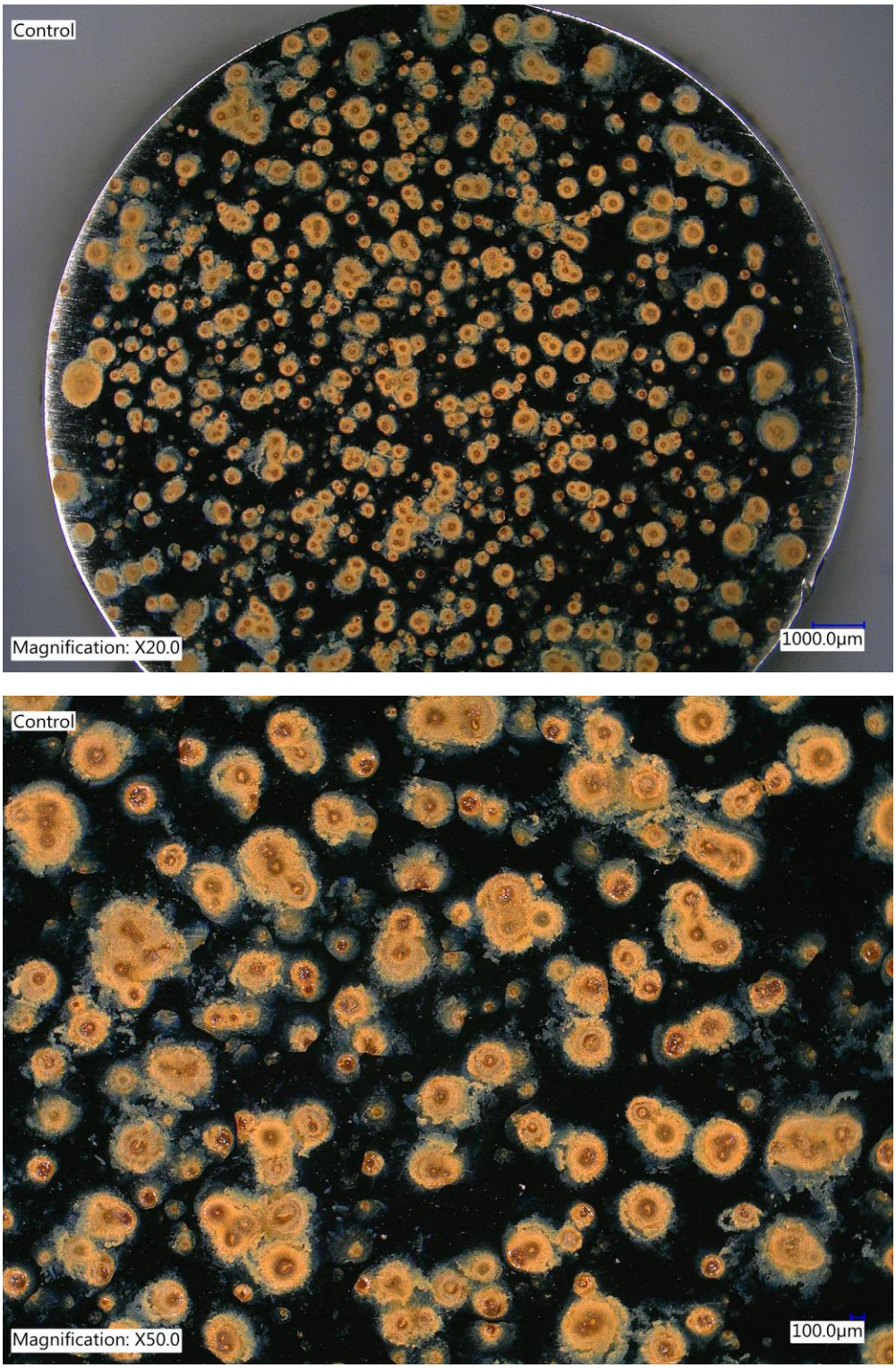
TM 208 VIA test on VpCI 309A



Control#2, grade 0

Fig. 3: Optical micrographs of the Control sample#2 in TM0208 VIA test.

TM 208 VIA test on VpCI 309A



Control#3, grade 0

Fig. 4: Optical micrographs of the Control sample#2 in TM0208 VIA test.

TM 208 VIA test on VpCI 309A

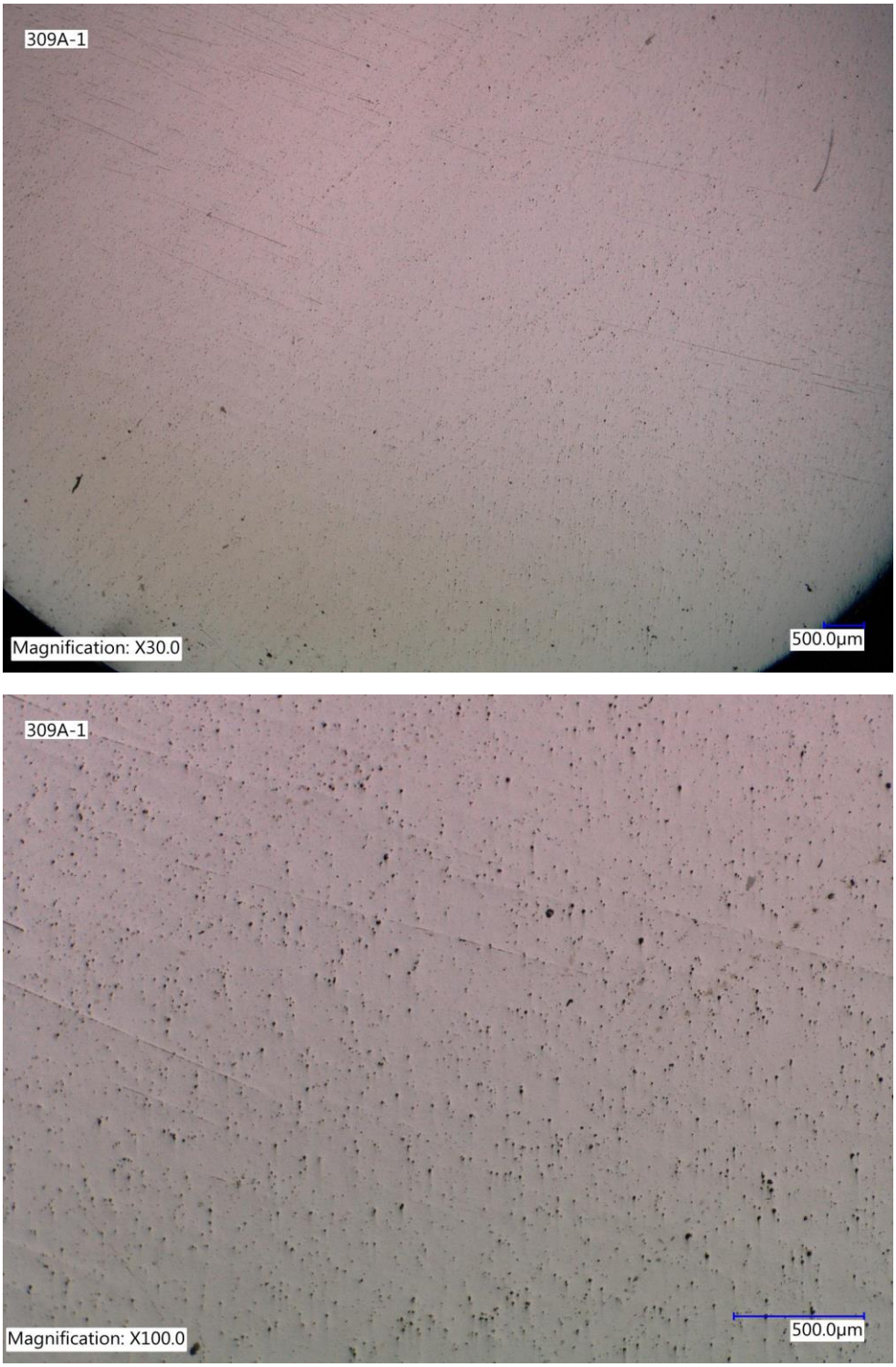
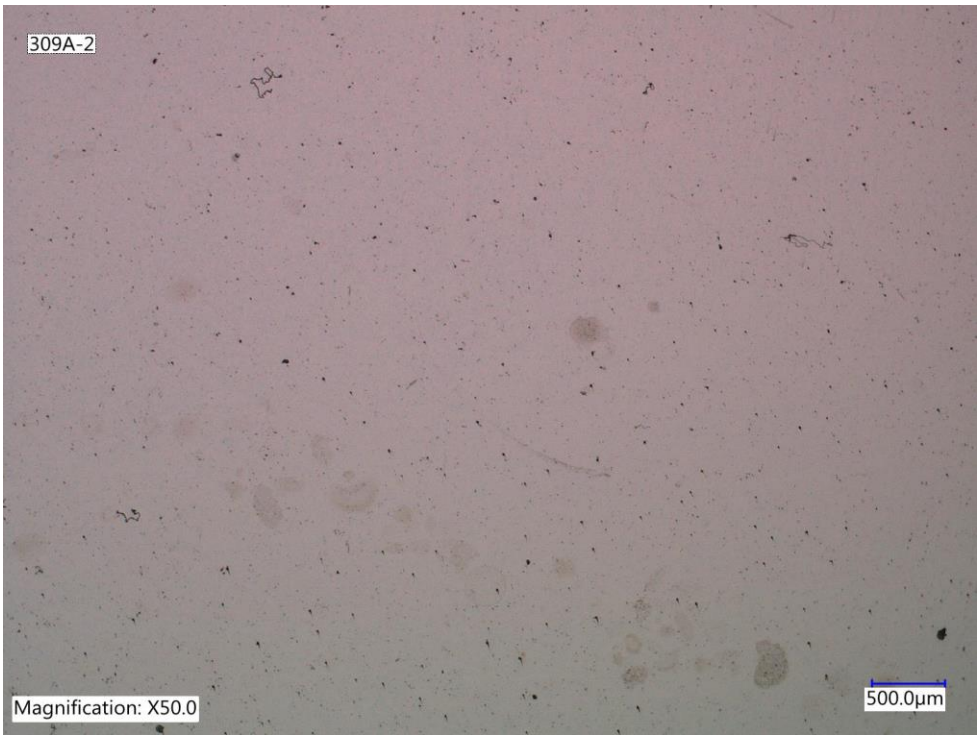


Fig. 5: Optical micrographs of the sample #1 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A



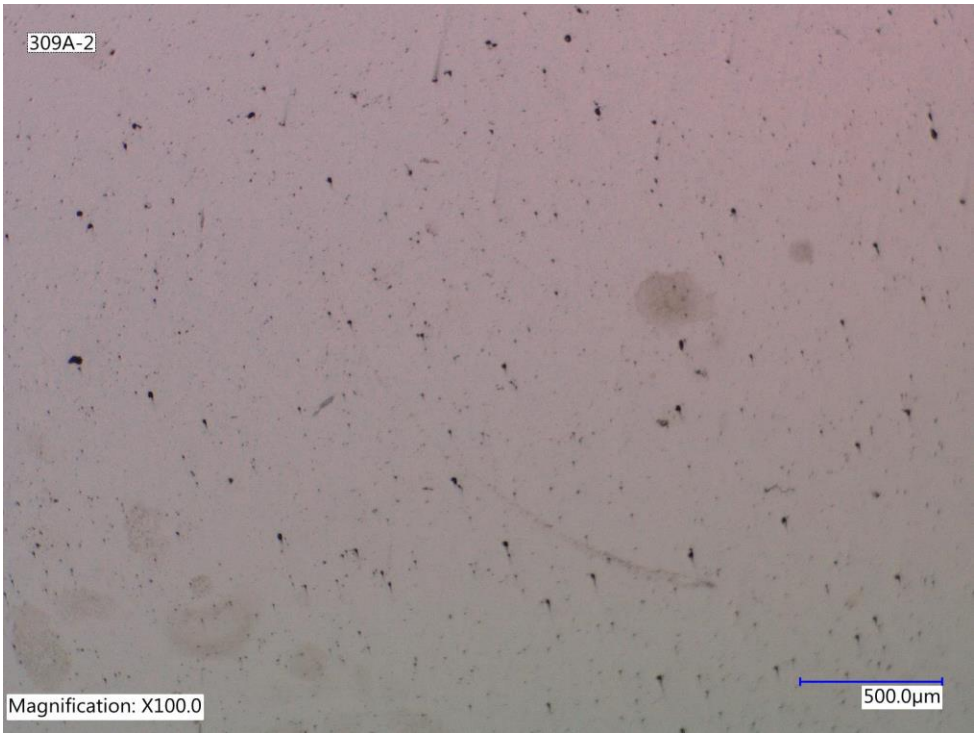
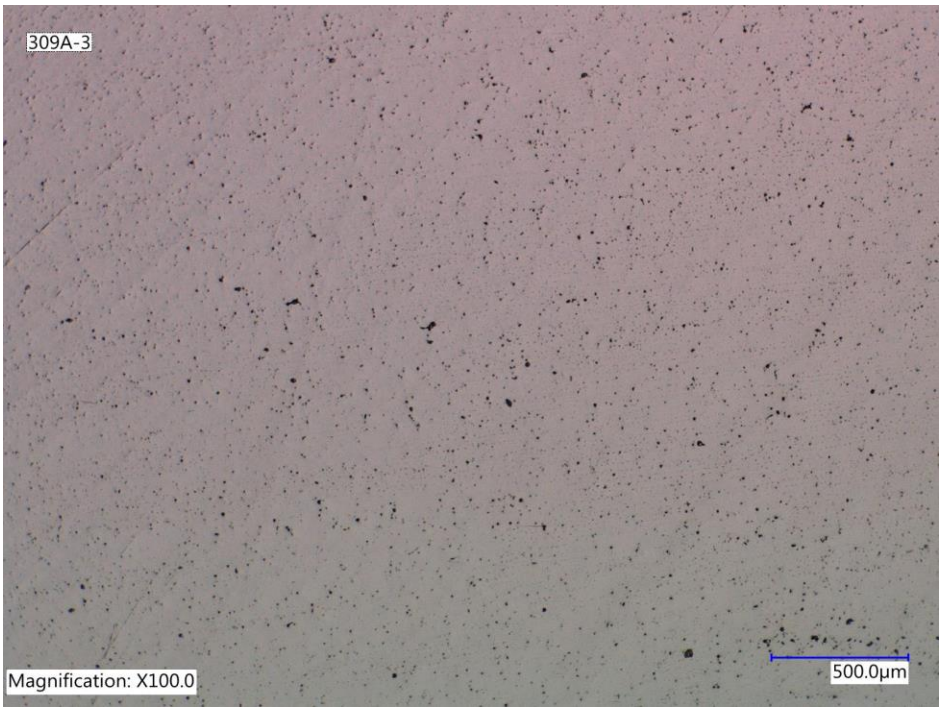


Fig. 6: Optical micrographs of the sample #2 exposed VpCI 309A in TM0208 VIA test , Grade 3.

TM 208 VIA test on VpCI 309A



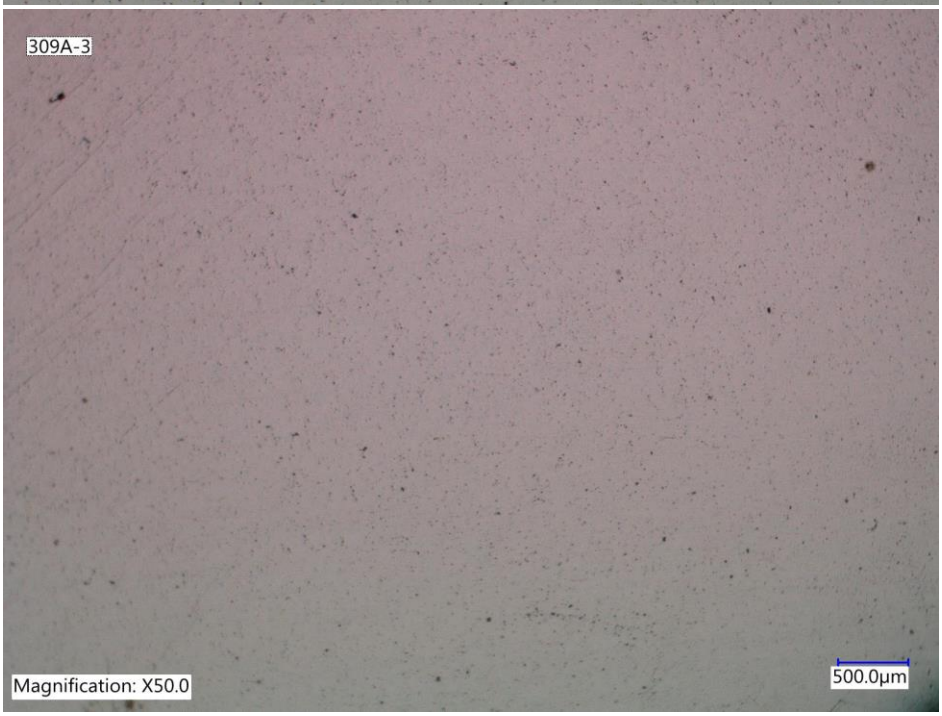


Fig. 7: Optical micrographs of the sample #3 exposed VpCI 309A in TM0208 VIA test, grade 3.

TM 208 VIA test on VpCI 309A

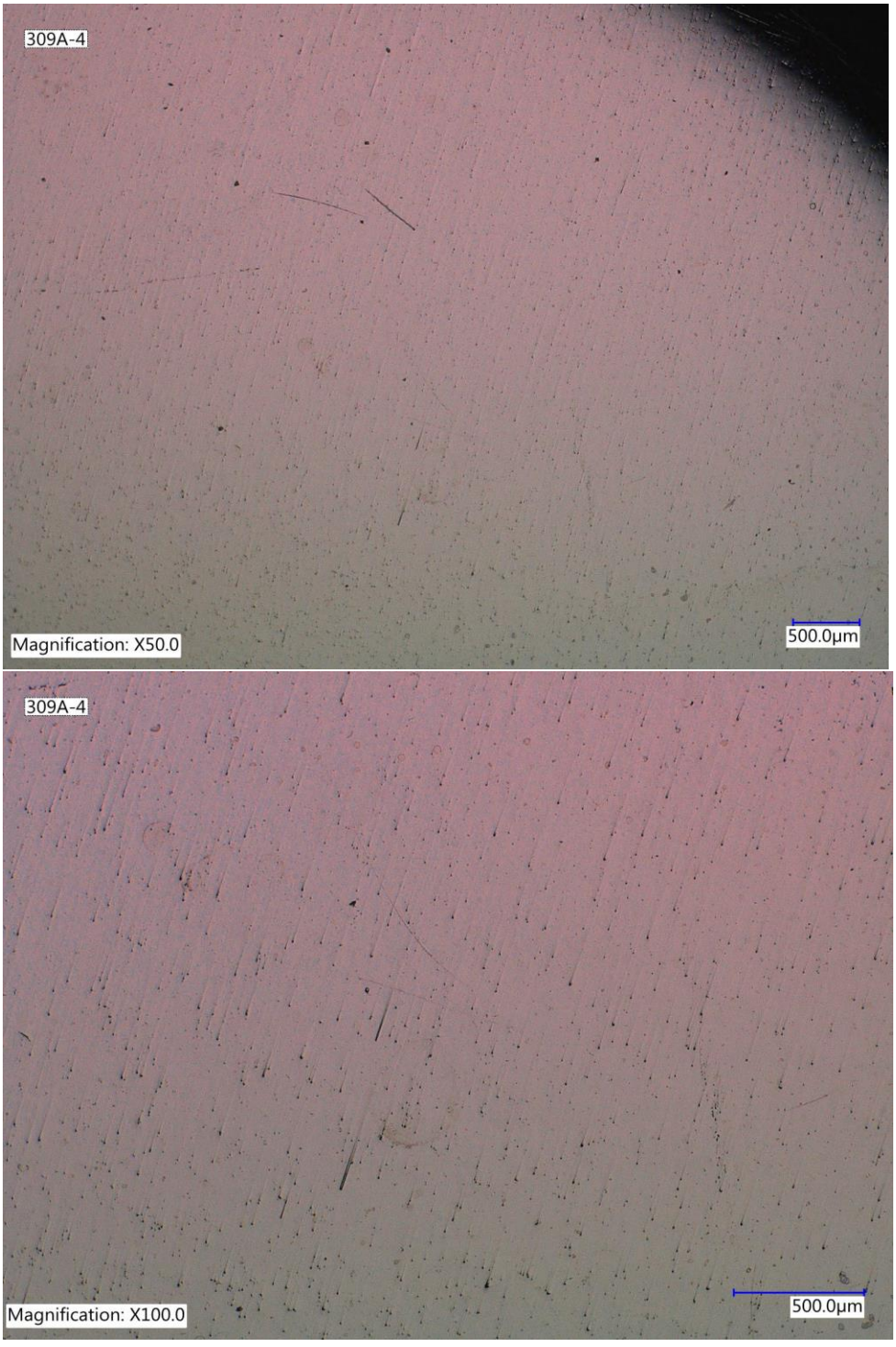


Fig. 8: Optical micrographs of the sample #4 exposed VpCI 309A in TM0208 VIA test, Grade 3.

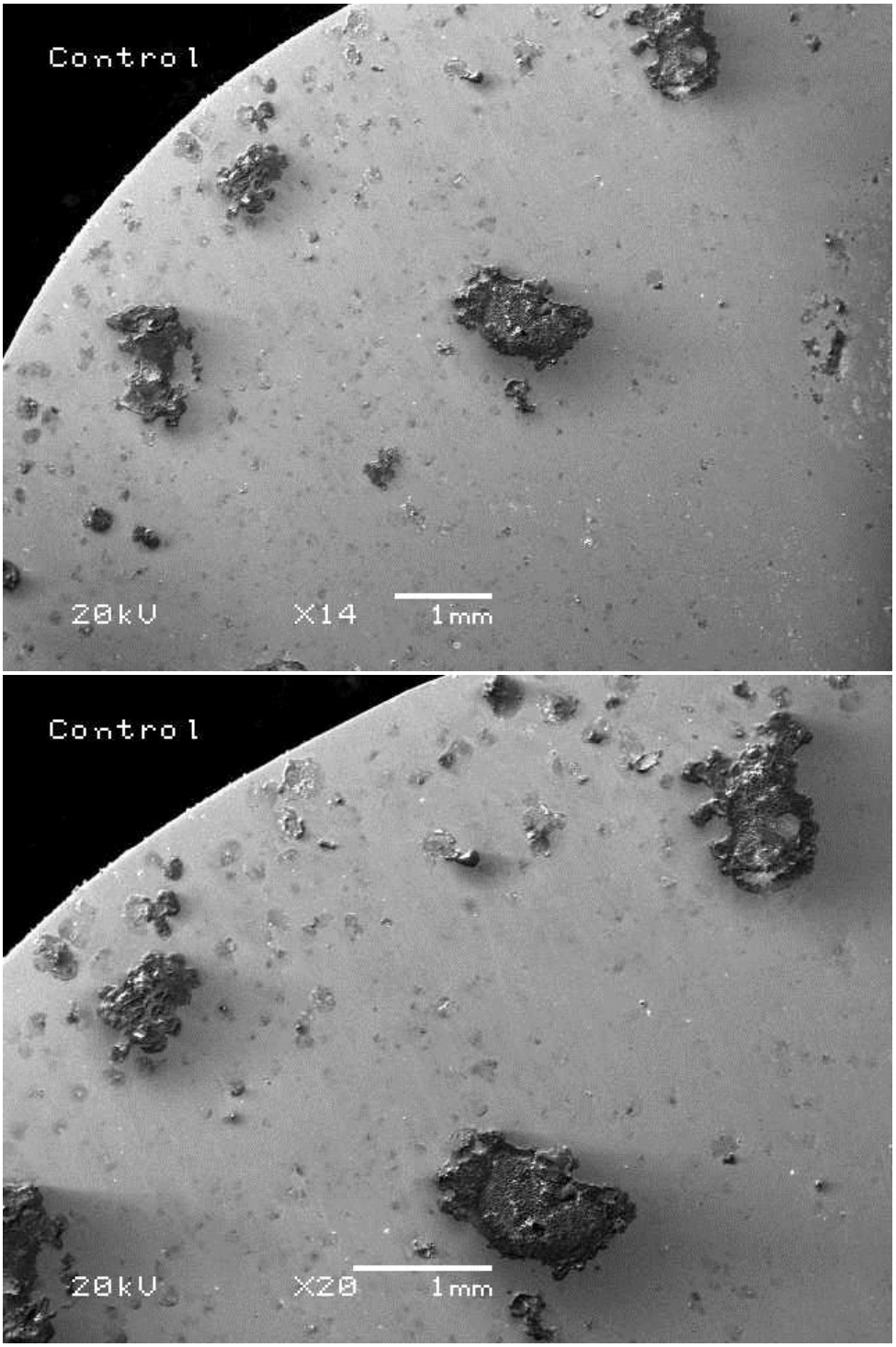


Fig. 9: SEM micrographs of the sample Control #1 in TM0208 VIA test, Grade 0.

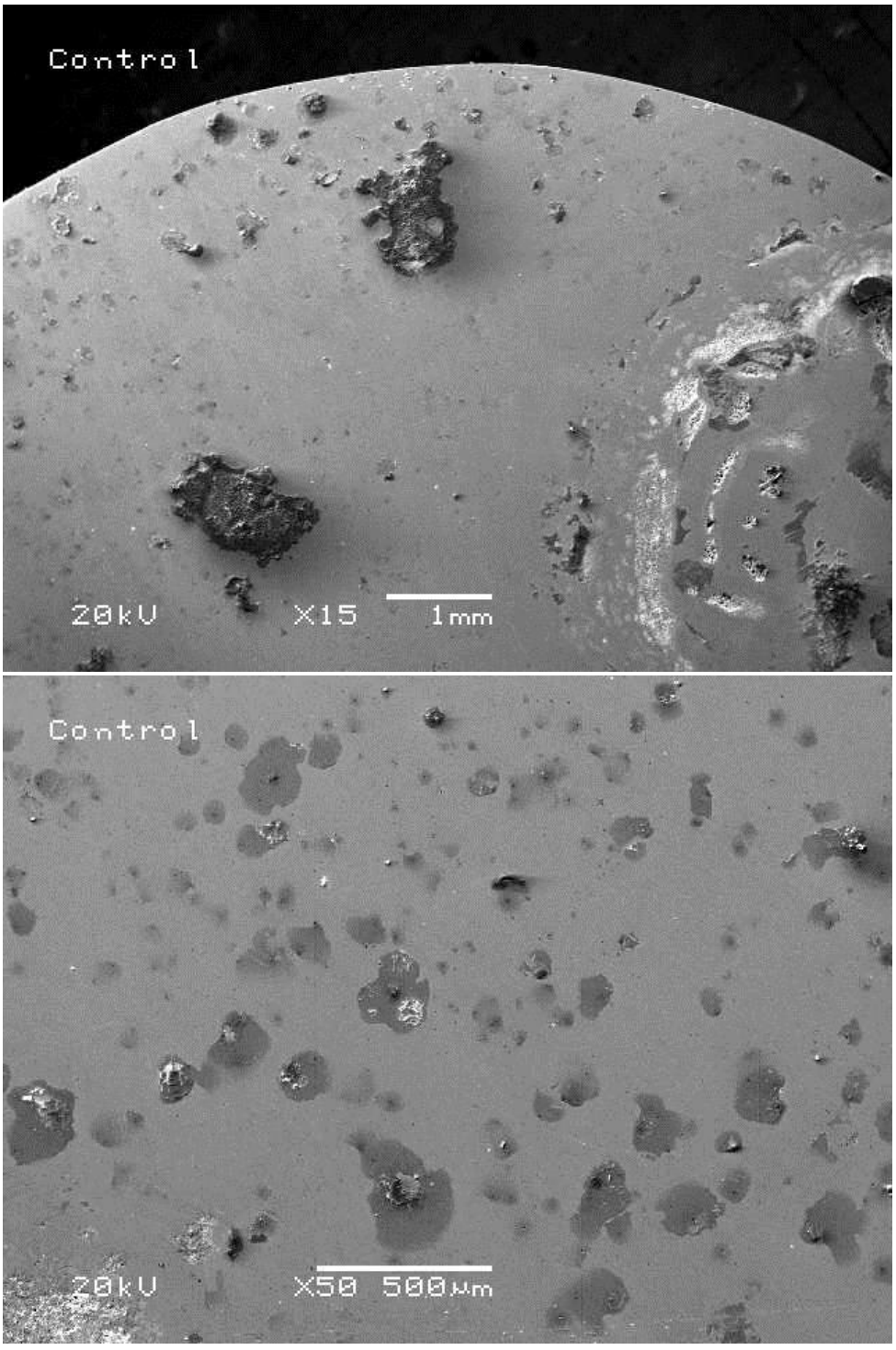


Fig. 10: SEM micrographs of the sample Control #1 in TM0208 VIA test, Grade 0.

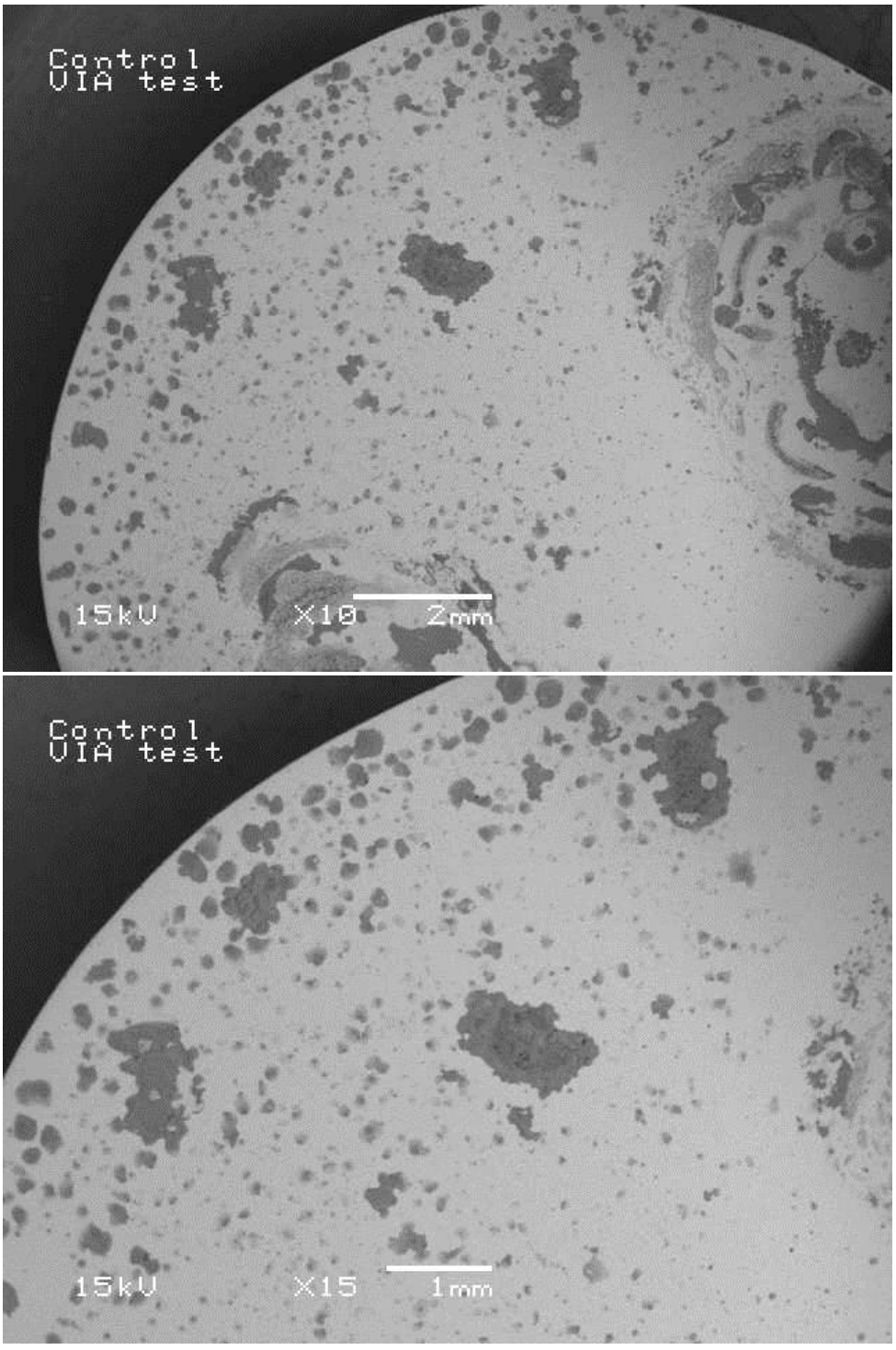


Fig. 11: SEM micrographs of the sample Control #1 in TM0208 VIA test, Grade 0.

TM 208 VIA test on VpCI 309A

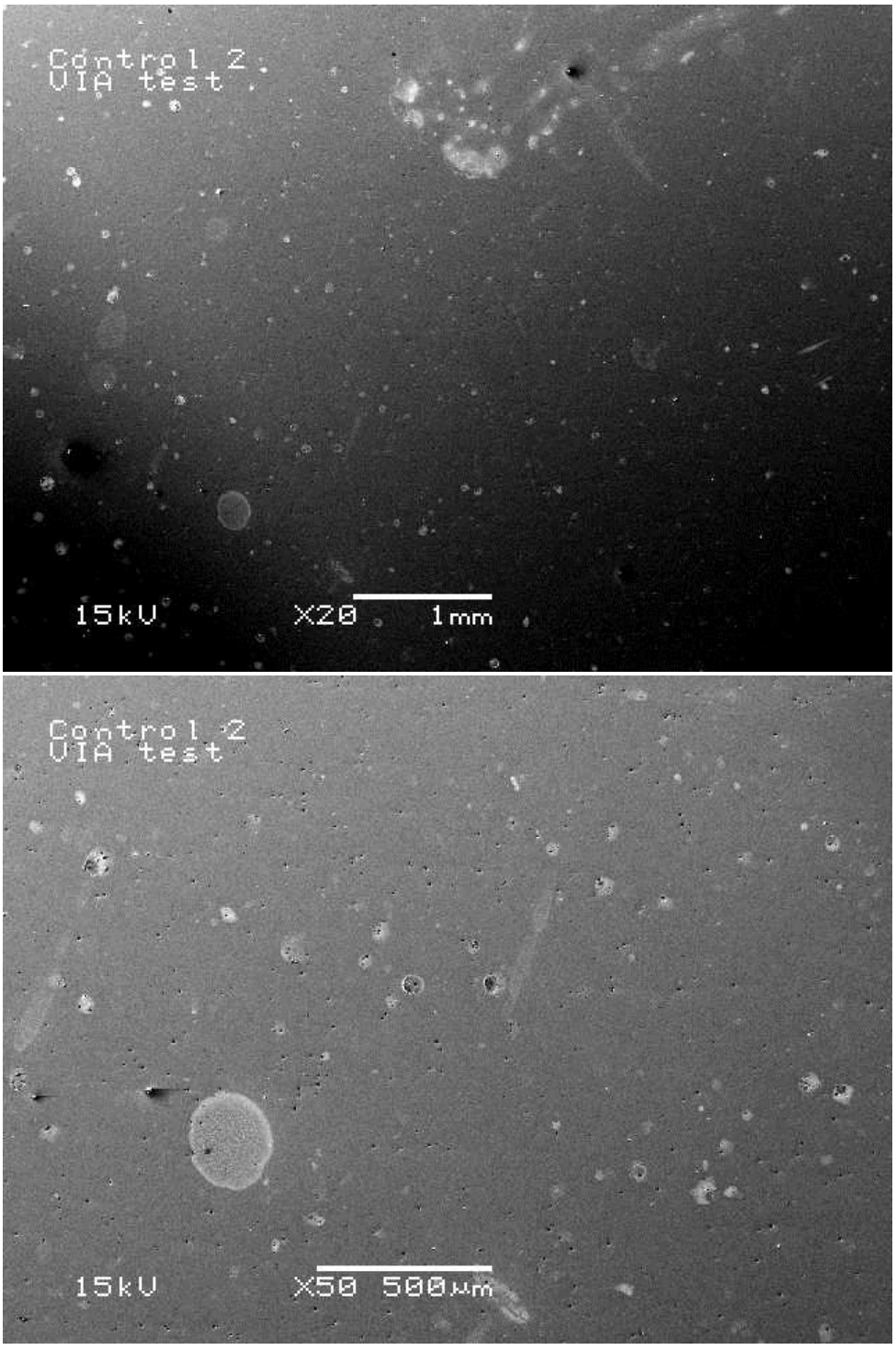


Fig. 12: SEM micrographs of the sample Control #2 in TM0208 VIA test, Grade 0.

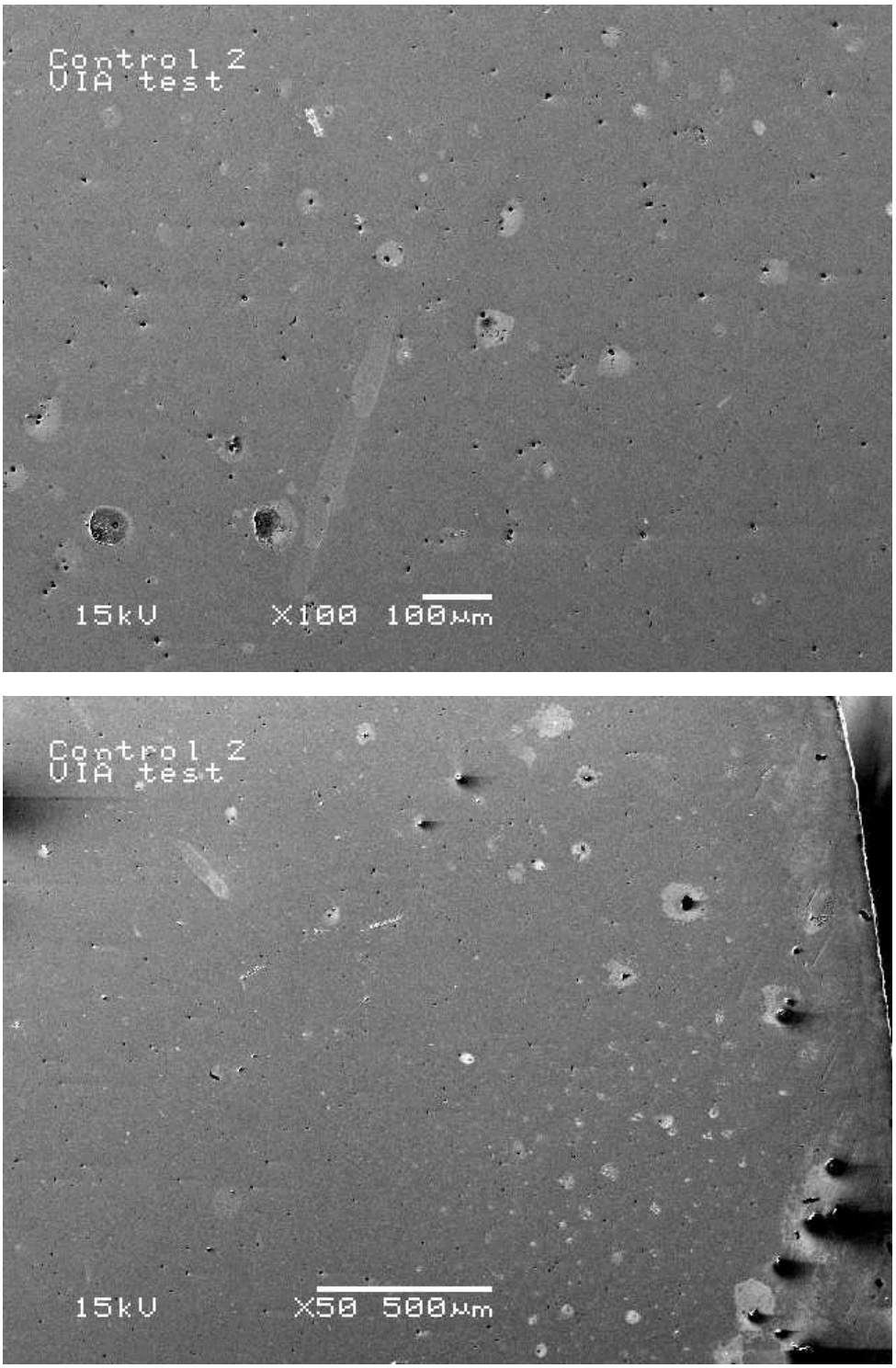


Fig. 13: SEM micrographs of the sample Control #2 in TM0208 VIA test, Grade 0.

TM 208 VIA test on VpCI 309A

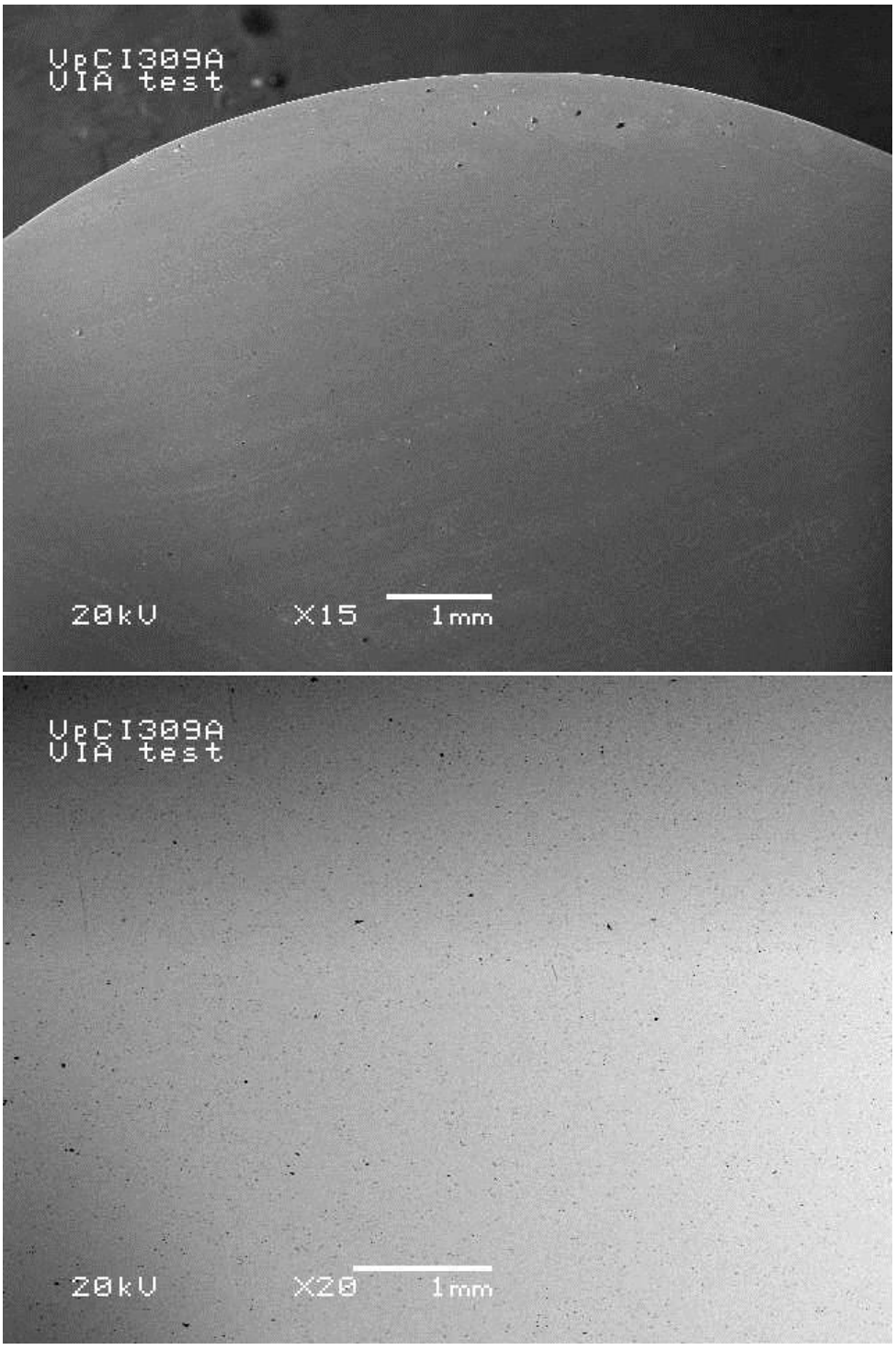


Fig. 14: SEM micrographs of the sample #1 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

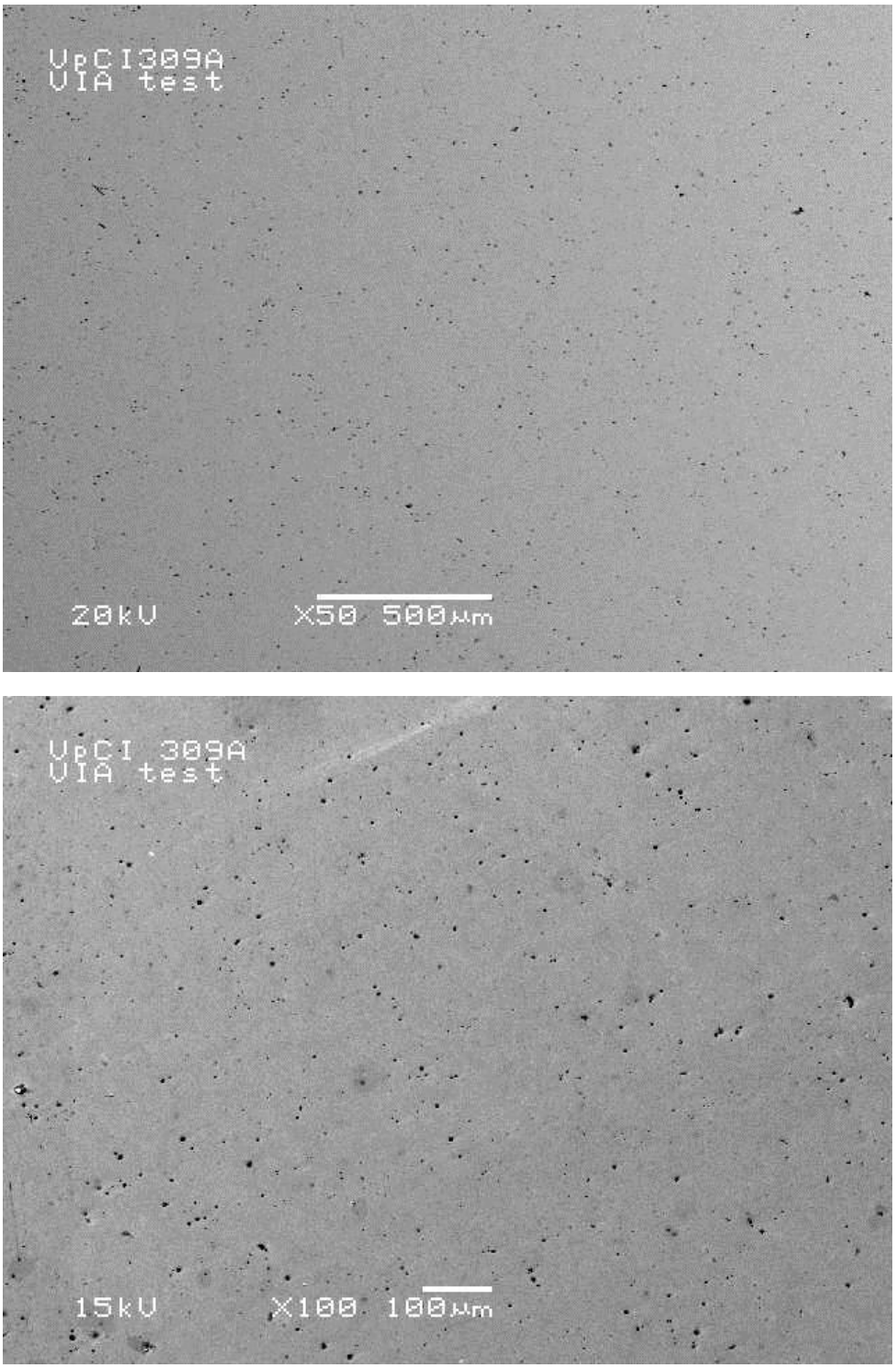


Fig. 15: SEM micrographs of the sample #1 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

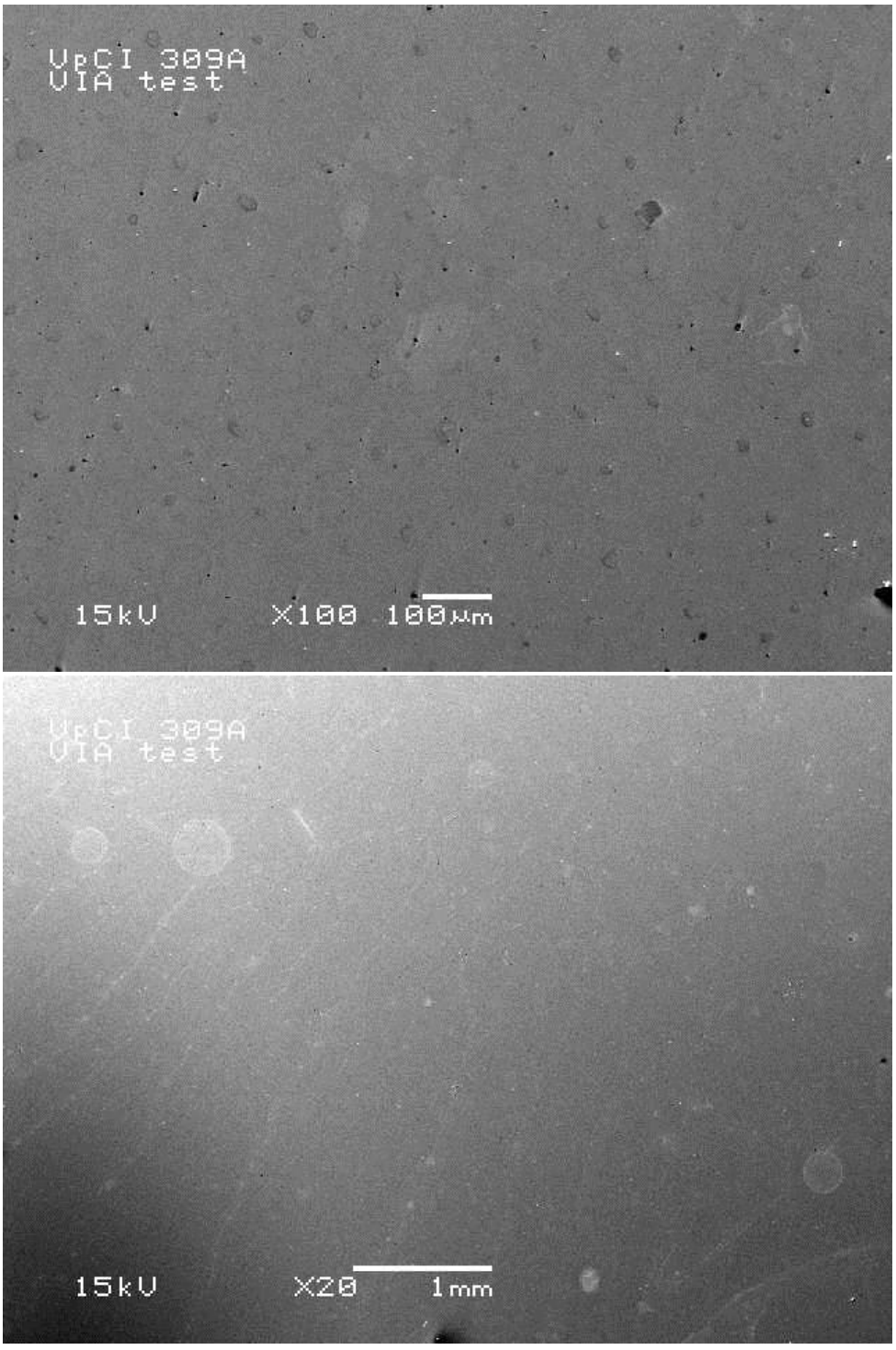


Fig. 16: SEM micrographs of the sample #1 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

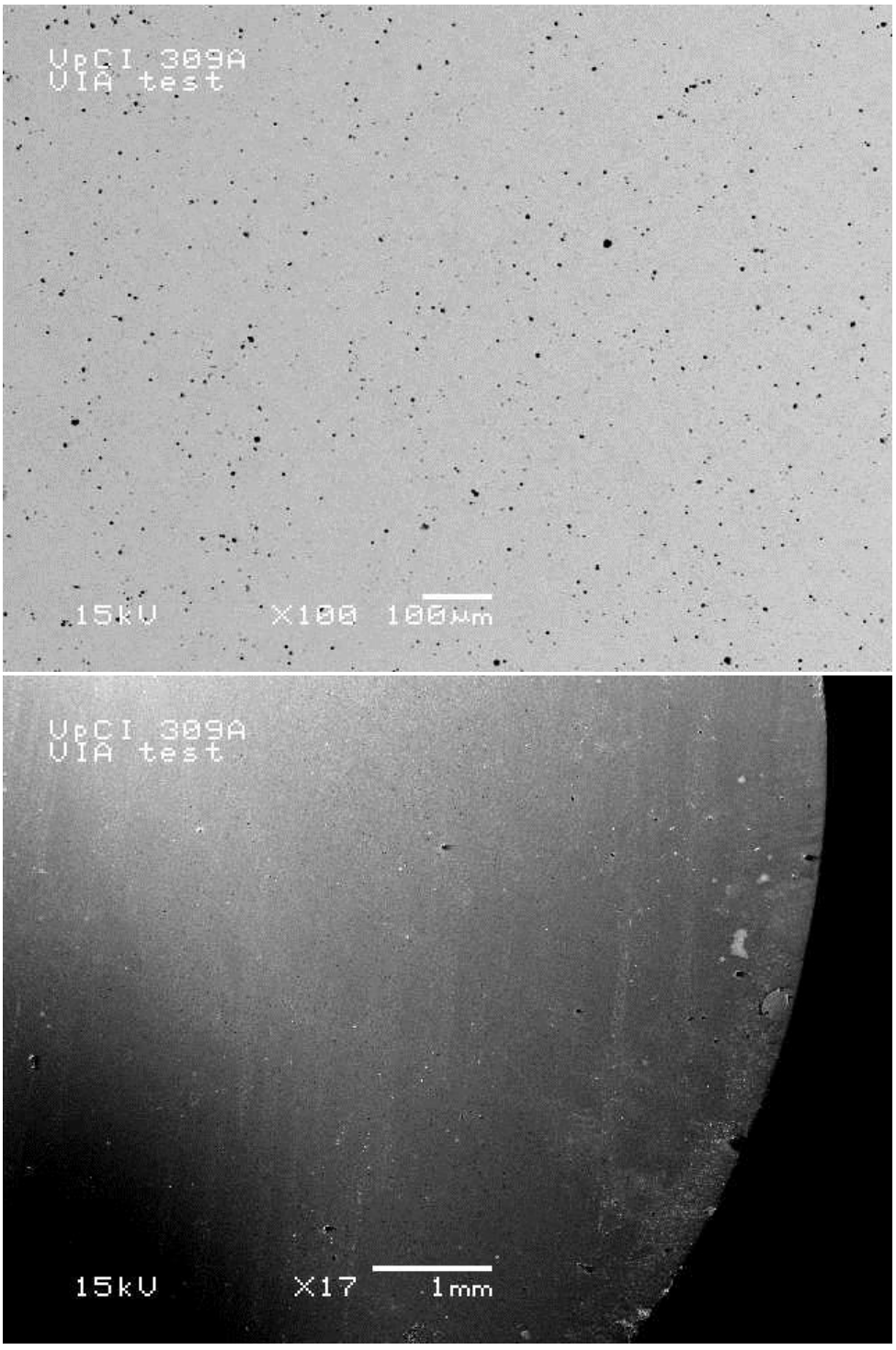


Fig. 17: SEM micrographs of the sample #2 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

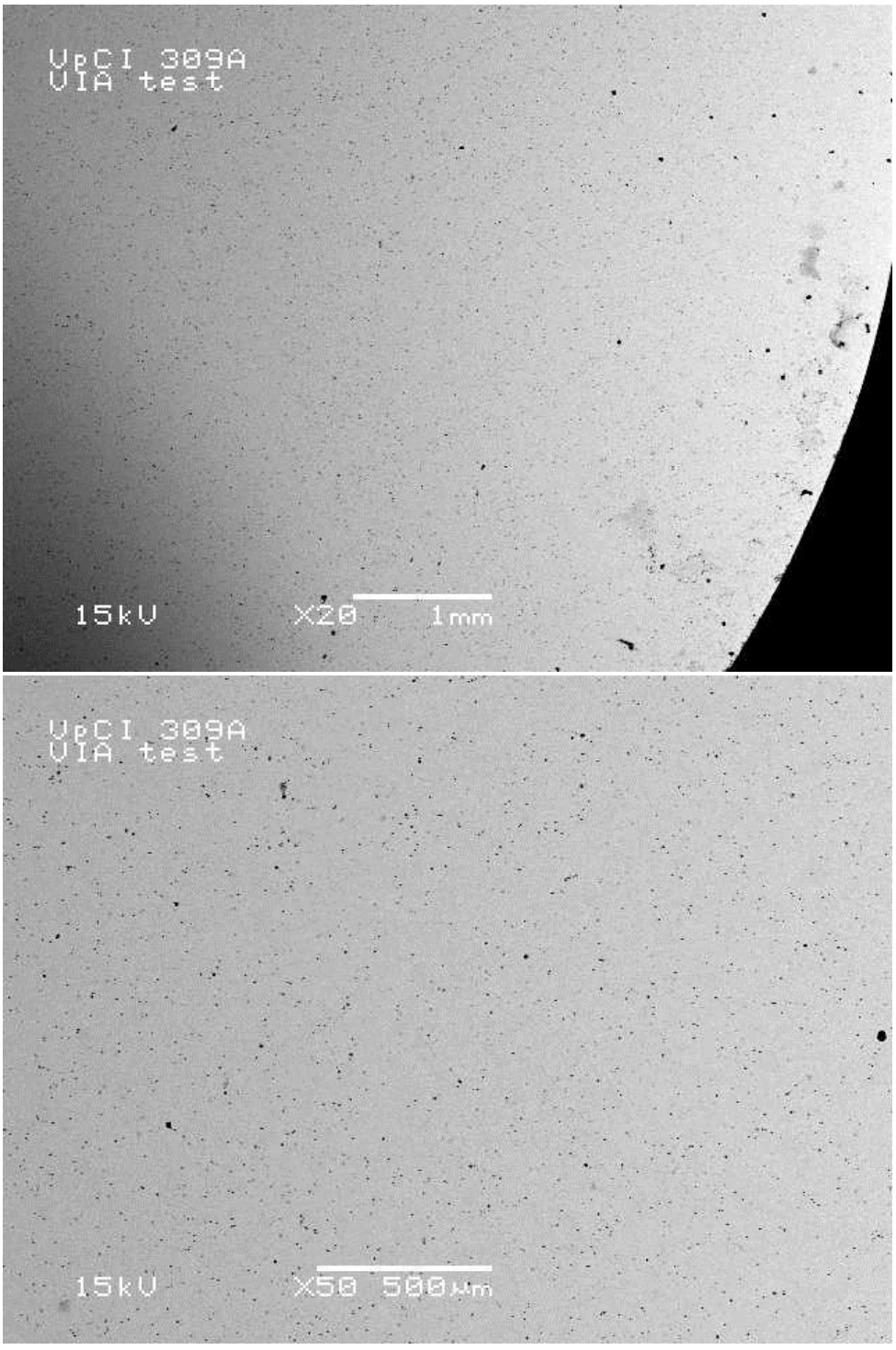


Fig. 18: SEM micrographs of the sample #3 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

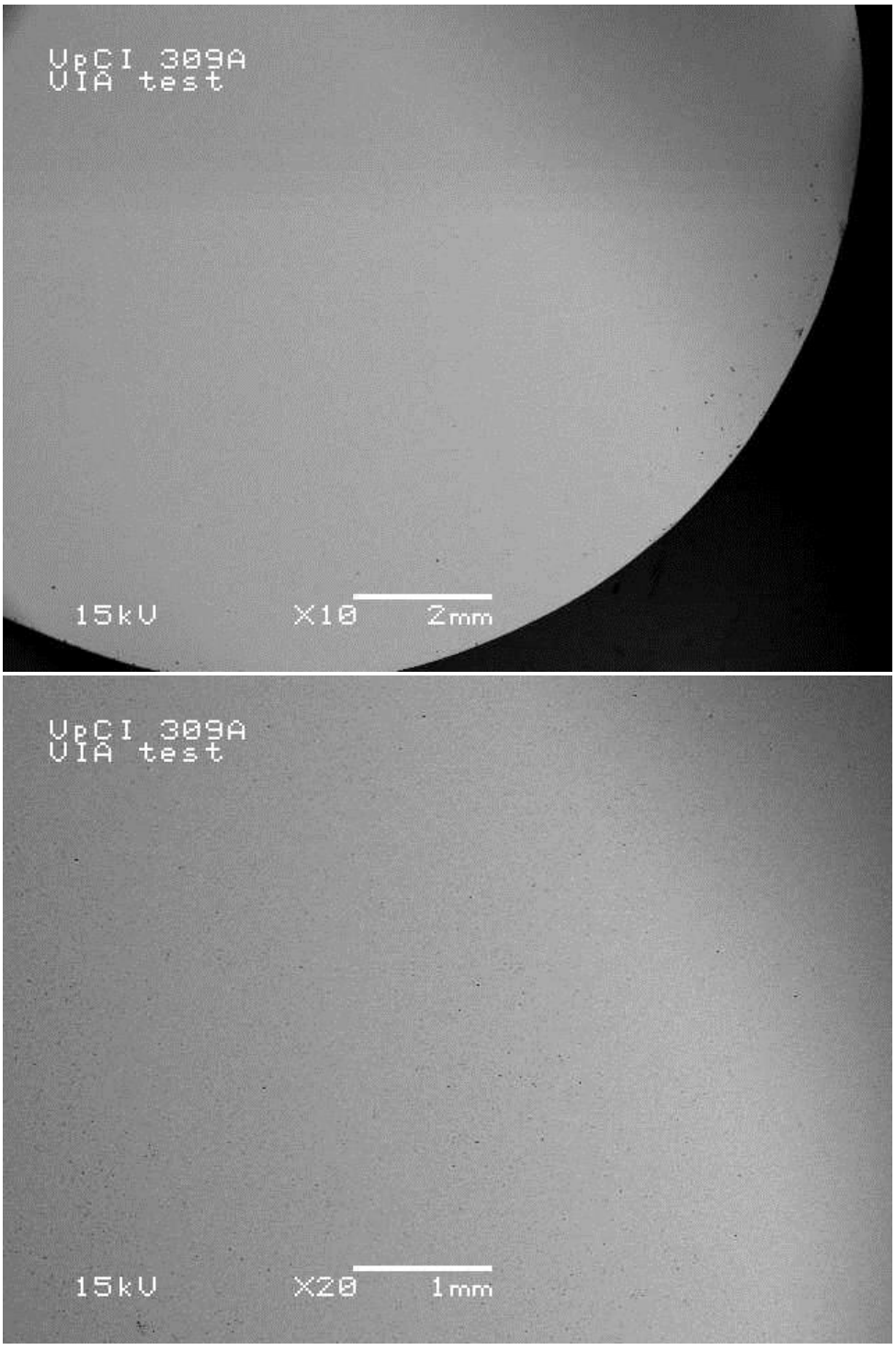


Fig. 19: SEM micrographs of the sample #4 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

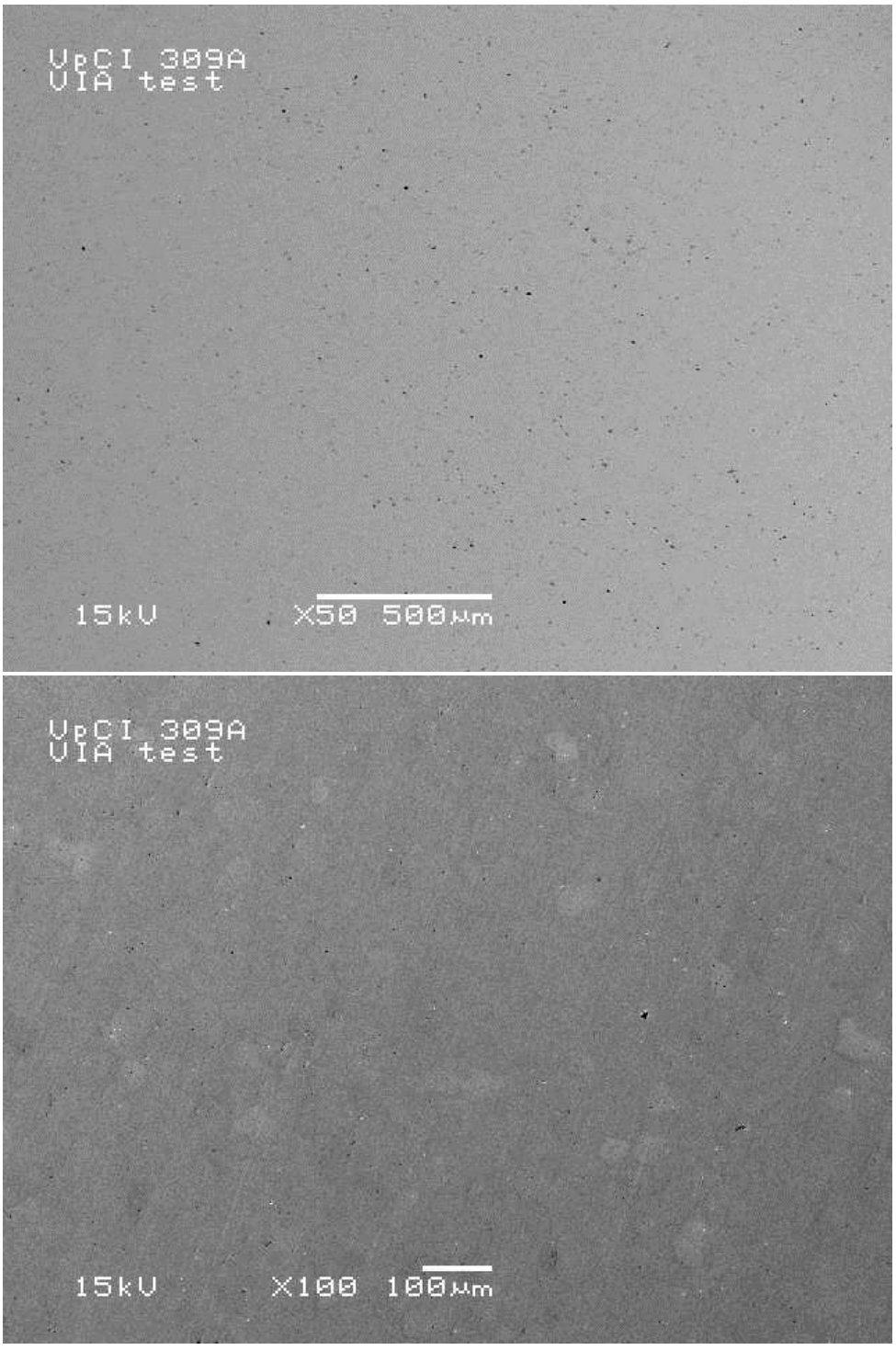


Fig. 20: SEM micrographs of the sample #4 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

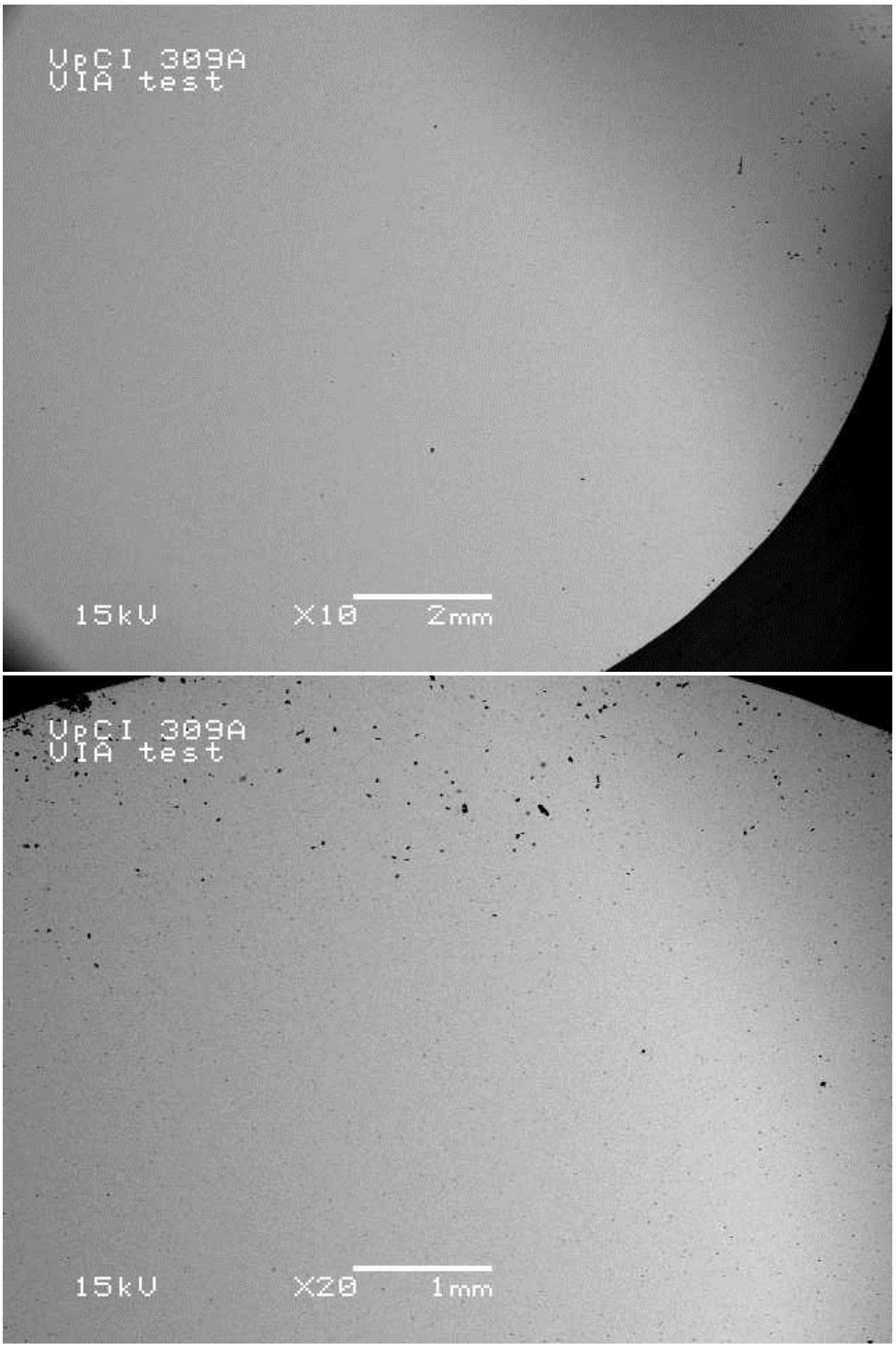


Fig. 21: SEM micrographs of the sample #5 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

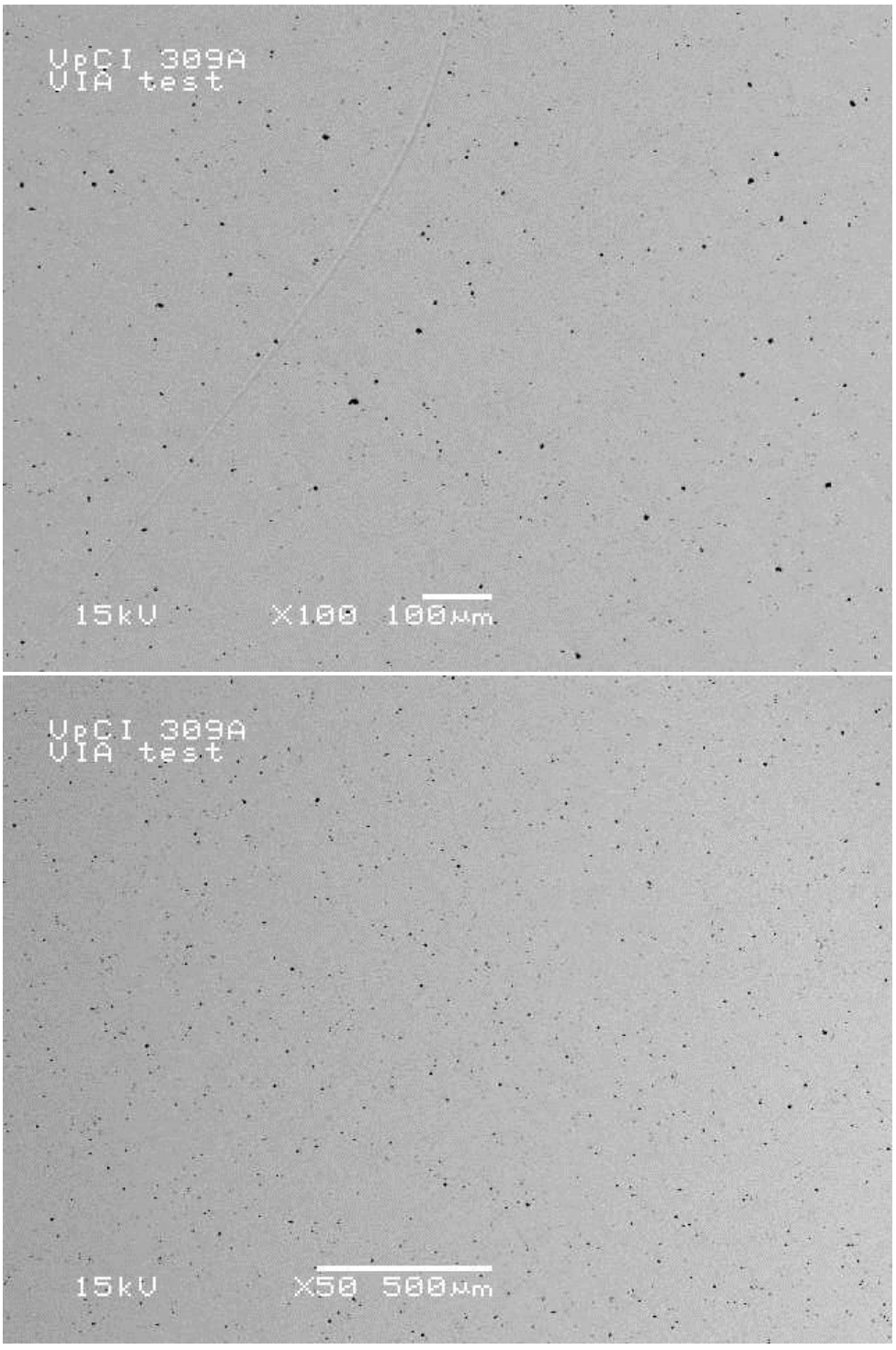


Fig. 22: SEM micrographs of the sample #5 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

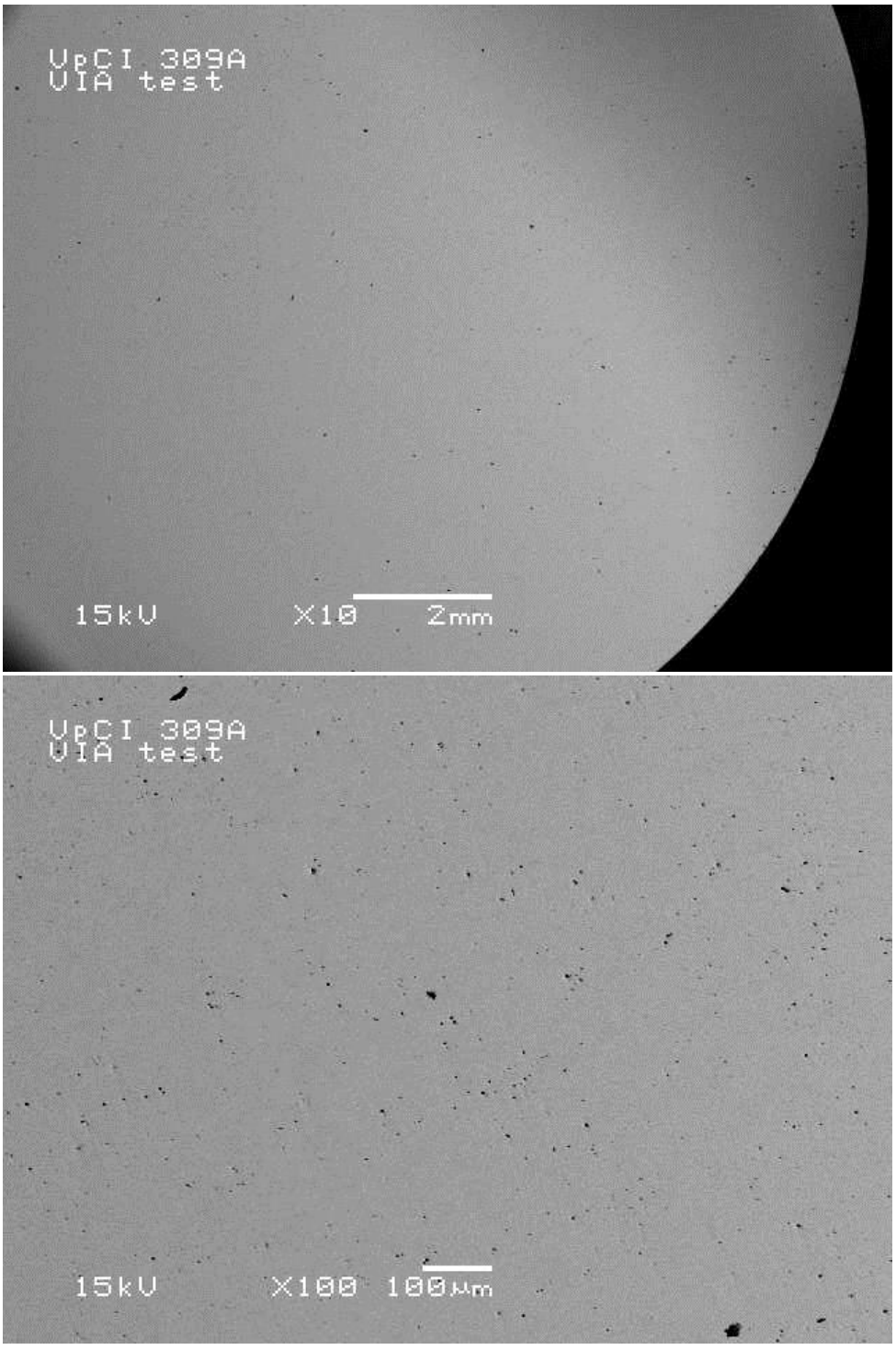


Fig. 23: SEM micrographs of the sample #6 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

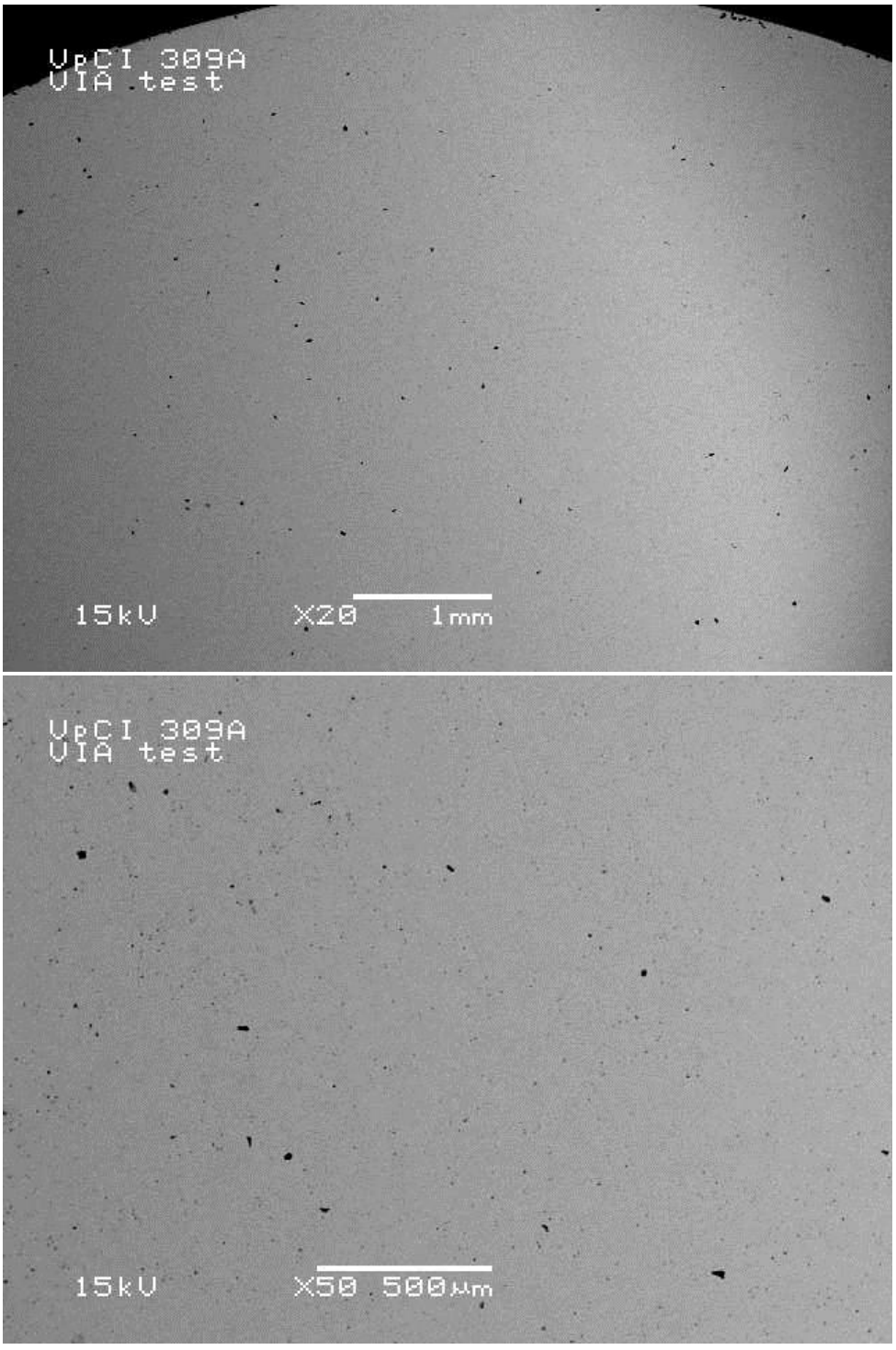


Fig. 24: SEM micrographs of the sample #6 exposed VpCI 309A in TM0208 VIA test, Grade 3.

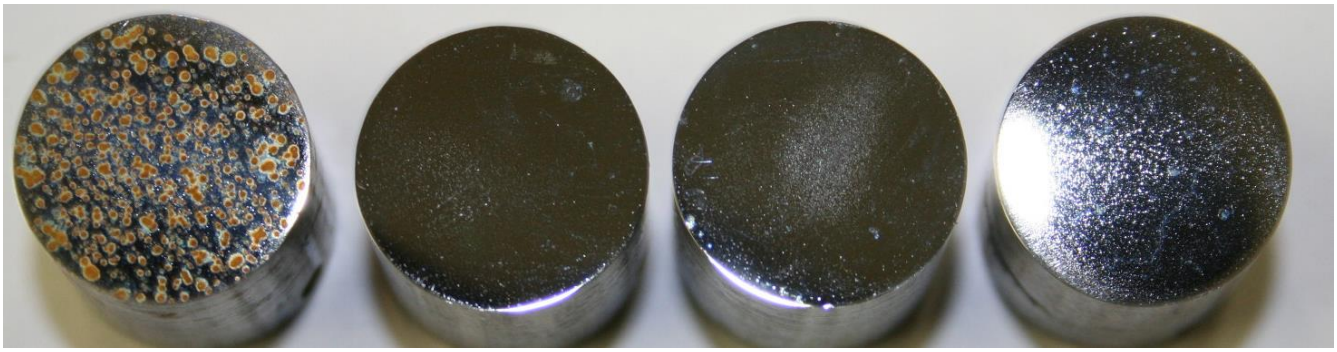


Fig. 25: Photos of the TM0208 VIA test#3, showed the control had grade 0 while the Exposed to VpCI 309A have grade 3.

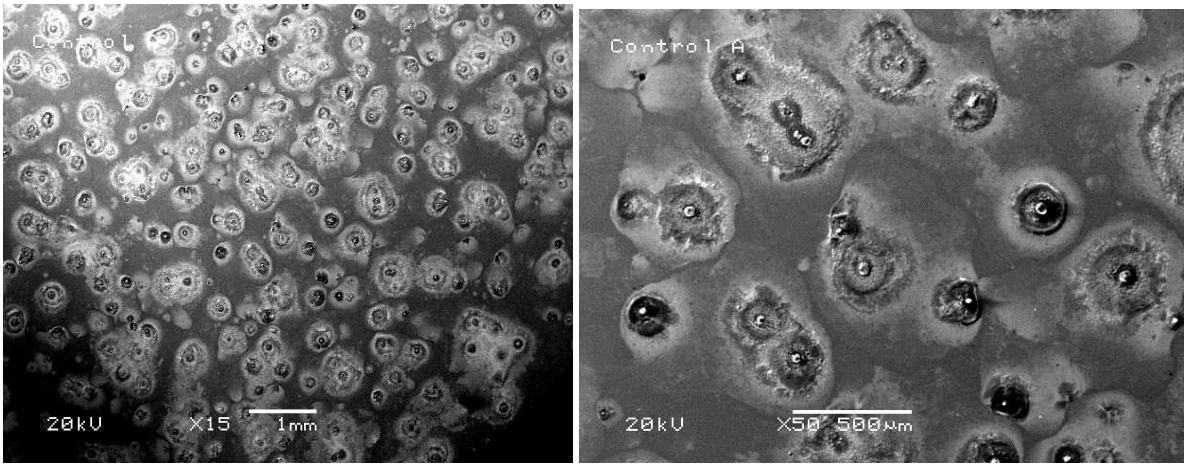


Fig. 26: SEM micrographs of TM0208 VIA test#3, showed the control had grade 0 (massive pitting corrosion).

TM 208 VIA test on VpCI 309A

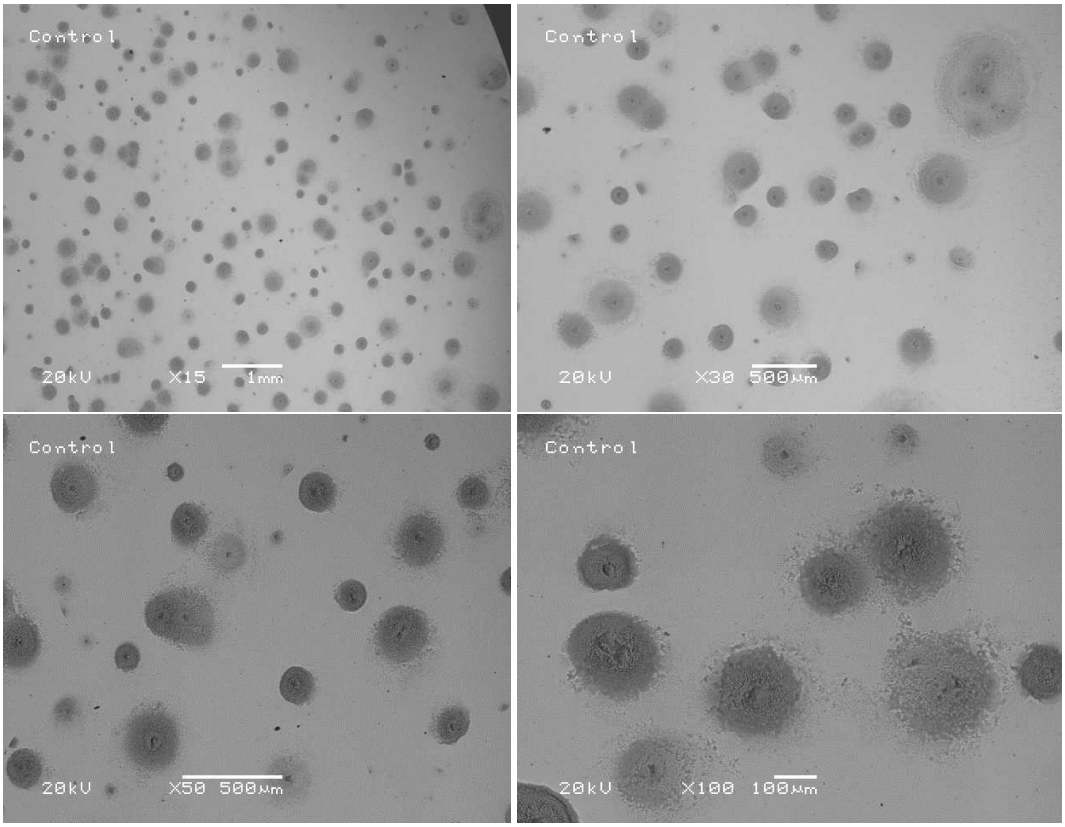


Fig. 27: SEM micrographs of TM0208 VIA test#3, showed the control had grade 0 (massive pitting corrosion).

TM 208 VIA test on VpCI 309A

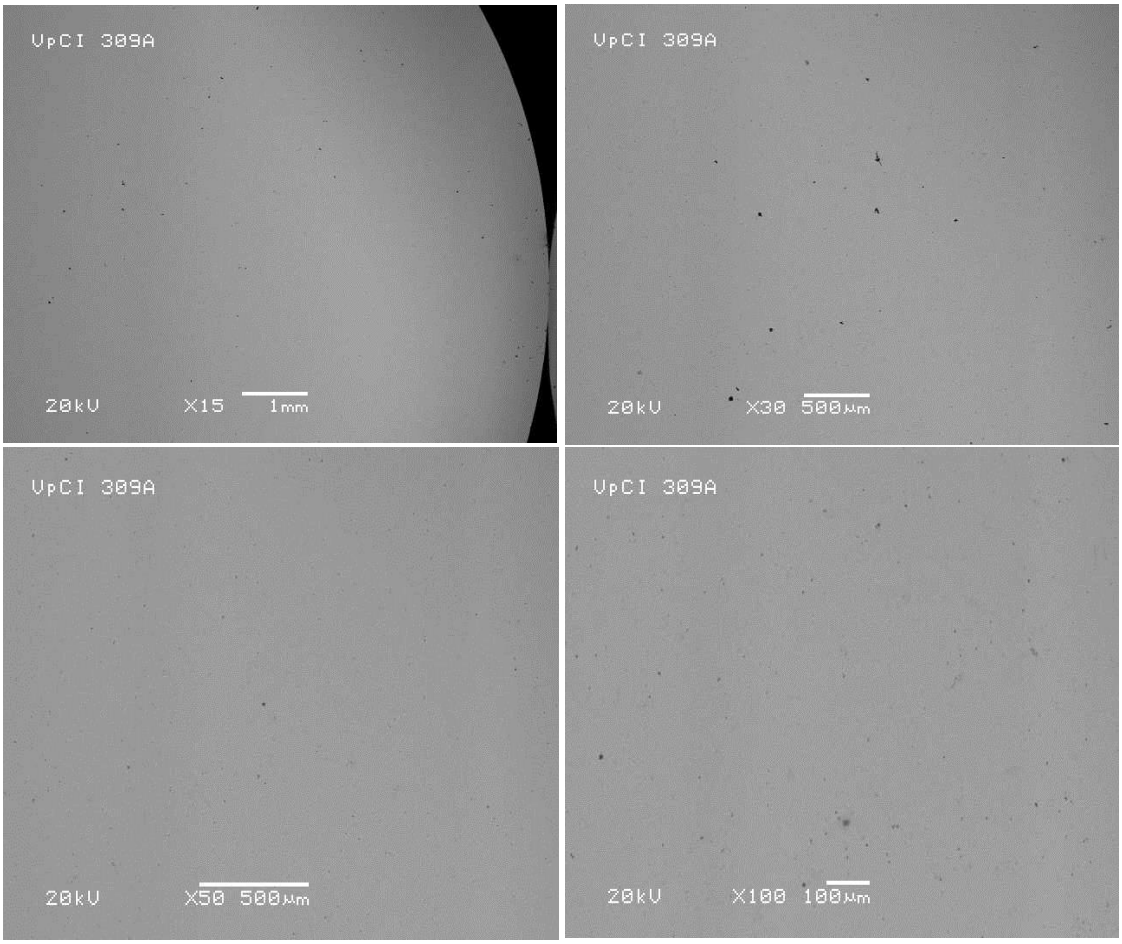


Fig. 28: SEM micrographs of the sample #7 exposed VpCI 309A in TM0208 VIA test, Grade 3.

TM 208 VIA test on VpCI 309A

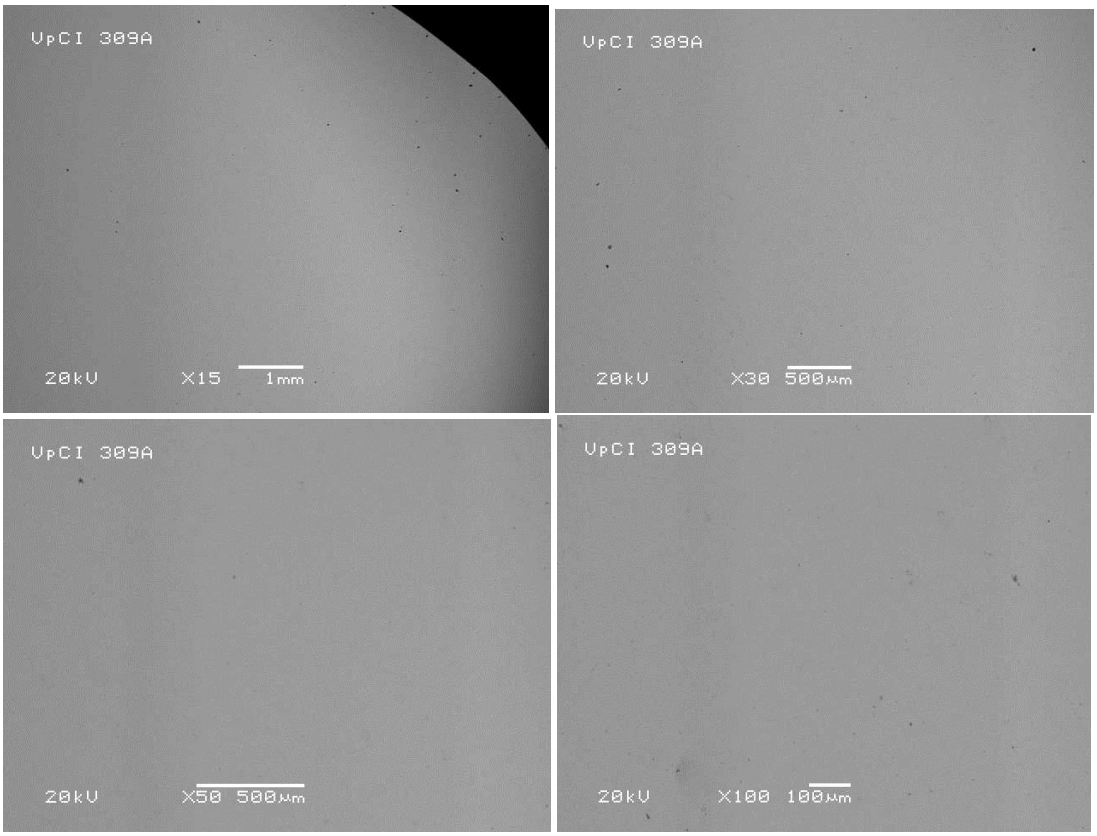


Fig. 29: SEM micrographs of the sample #8 exposed VpCI 309A in TM0208 VIA test, Grade 3

TM 208 VIA test on VpCI 309A

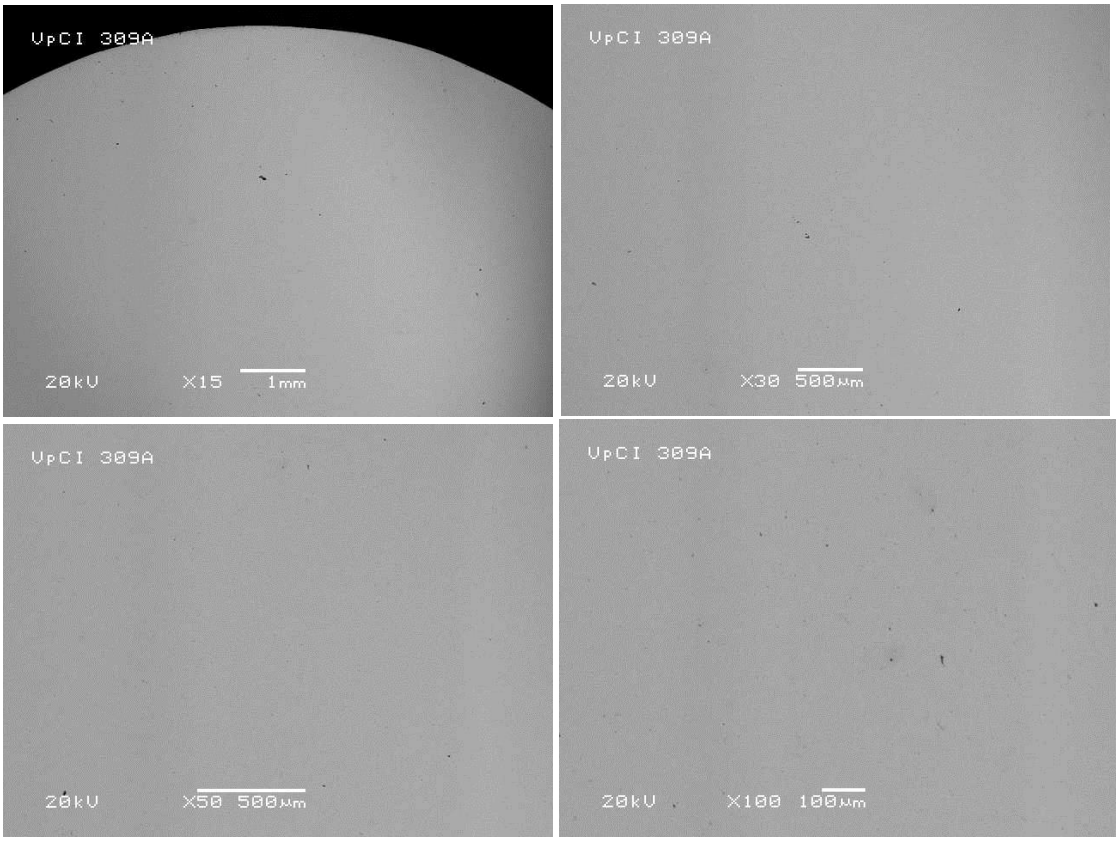
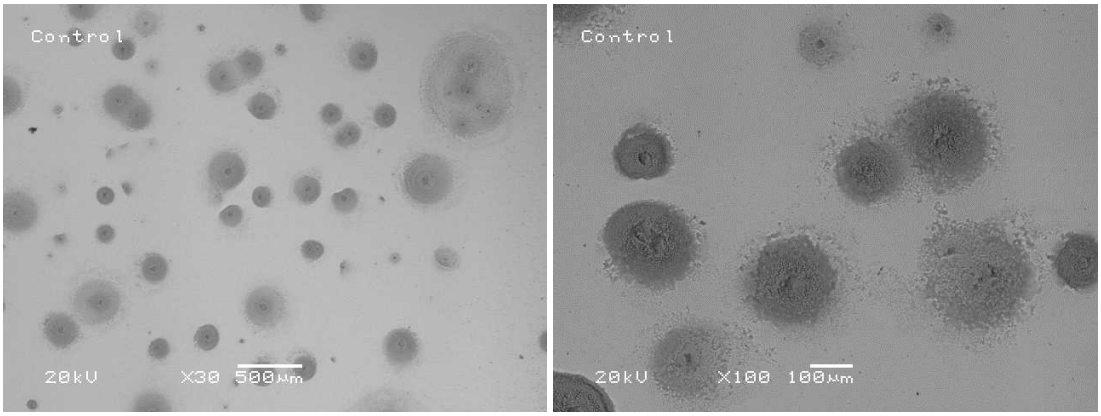
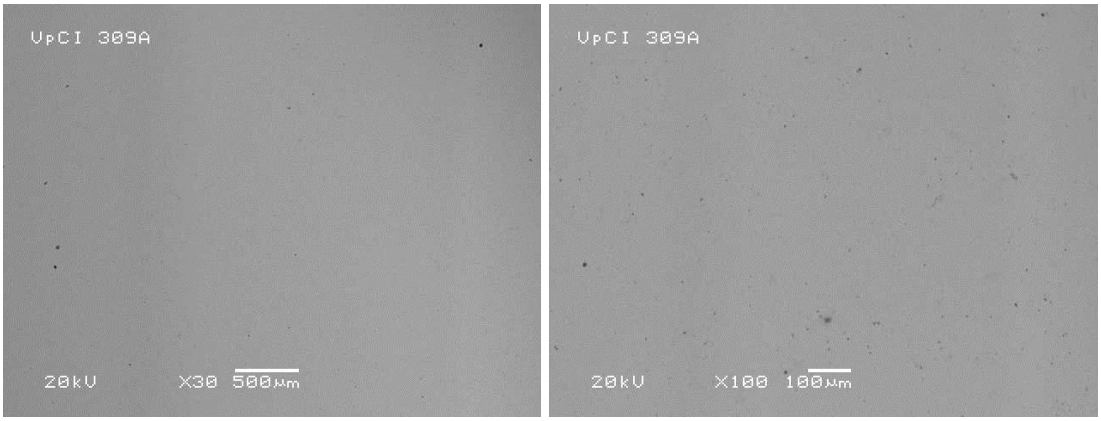


Fig. 30: SEM micrographs of the sample #9 exposed VpCI 309A in TM0208 VIA test, Grade 3

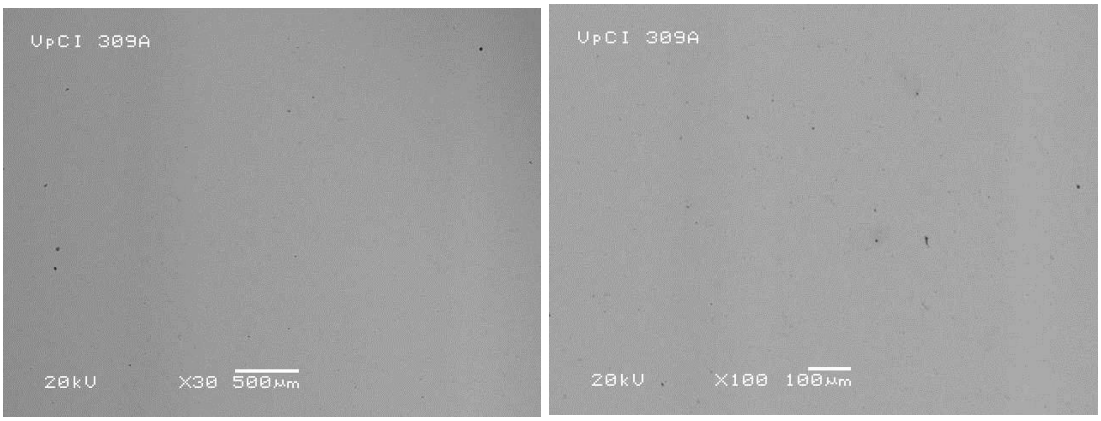
TM 208 VIA test on VpCI 309A



Control grade 0



VpCI309A, grade 3



VpCI309A, grade 3

Fig. 31: Comparison of different samples exposed VpCI 309A and control in TM0208 VIA test.